

**DRAFT**

**SAMPLING AND ANALYSIS PLAN**

**VERSION 0**

**SEPTEMBER, 2001**

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DRAFT

**SAMPLING AND ANALYSIS PLAN (SAP)**  
**SLAG INVESTIGATION**  
**THE DOE RUN COMPANY LEAD SMELTER**  
**HERCULANEUM, MISSOURI**

**DOCKET NO.**  
**RCRA-7-2000-0018**  
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**SEPTEMBER, 2001**

**Prepared For:**

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***DOE RUN***  
**COMPANY**

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*#99-0034-SOP-03 for Collecting Freshwater Fishes for the Purposes of Tissue Analysis in the State of Missouri;*  
*#99-0034-SOP-04 for Conducting an Index of Biotic Integrity Survey in the State of Missouri;*  
*#99-0034-SOP-05 for the Qualitative Stream Habitat Assessment Procedure;*  
*#99-0034-SOP-06 for the Physical Characterization/Water Quality and Habitat Assessment;*  
*#99-0034-SOP-07 for the Quantitative Floristic Community Survey;*  
*#99-0034-SOP-8 for Collecting Dissolved Oxygen Data in Freshwater Ecosystems;*  
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*#99-0034-SOP-13 for the Collection of Redox Potential (ORP) Data in Freshwater Ecosystems; and*  
*#99-0034-SOP-14 for the Qualitative Floristic Community Survey*

### **Appendix B – Letter from the Missouri Department of Conservation Describing Natural Resources Information for the Herculaneum Area;**

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**LIST OF ACRONYMS**

ACOE – United States Army Corps of Engineers  
AOC – Administrative Order on Consent  
BRA – Baseline Risk Assessment  
CERCLA – Comprehensive Environmental Response, Compensation and Liability Act of 1980  
COC – Chain of Custody  
COPC – Constituent of Potential Concern  
CSM – Conceptual Site Model  
DO – Dissolved Oxygen  
DQO – Data Quality Objective  
EC – Electrolytic Conductance  
ERA – Ecological Risk Assessment  
IBI – Index of Biotic Integrity  
IEPA – Illinois Environmental Protection Agency  
MDNR – Missouri Department of Natural Resources  
MDC – Missouri Department of Conservation  
MBI – Macroinvertebrate Biotic Index  
NA – Not Applicable  
NRDA – Natural Resource Damage Assessment

NWI - National Wetland Inventory  
ORP - Redox Potential  
PSD - Particle Size Distribution  
QA - Quality Assurance  
QAPP - Quality Assurance Project Plan  
QA/QC - Quality Assurance/Quality Control  
QC - Quality Control  
RAM - Resource Assessment and Monitoring  
SAP - Sampling and Analysis Plan  
SHAP - Stream Habitat Assessment Procedure  
SI - Slag Investigation  
SOP - Standard Operating Procedure  
TAL - Target Analyte List  
TBD - To Be Determined  
TSS - Total Suspended Solids  
USEPA - United States Environmental Protection Agency  
USFWS - United States Fish and Wildlife Service

**1 Introduction**

This Sampling and Analysis Plan (Plan) is submitted to the United States Environmental Protection Agency (USEPA) – Region VII and the Missouri Department of Natural Resources (MDNR) by The Doe Run Resources Corporation (Doe Run) pursuant to the Administrative Order on Consent – Docket No. VII-99- (AOC) (date pending). This Plan has been written to fulfill requirements outlined in the AOC including the scope of work. The AOC and this Plan concern the slag pile storage area of the Doe Run lead smelter at 881 Main Street in Herculaneum, Jefferson County, Missouri (hereinafter referred to as the "Site") as well as slag pile/surface water/sediment/groundwater/surface soil areas potentially affected by the Site (Figure 1). Included in this investigation is the characterization of Joachim Creek and the Mississippi River floodplain as well as nearby portions of the Mississippi River (hereinafter referred to as the "Study Area") located adjacent to the Site. In addition to this Plan, other AOC required workplans include:

- Quality Assurance Project Plan (QAPP);
- Natural Resource Damage Assessment (NRDA) Plan;
- Health and Safety Plan;
- Community Soil Cleanup Plan;
- Community Blood Lead Plan;
- Interim Slag Pile Runoff Control Plan;
- Ecological Risk Assessment (ERA) Workplan; and
- Groundwater Monitoring Plan.

References will be made to several of these documents with special attention given to the QAPP and the ERA workplan. The QAPP, the ERA workplan and this Plan are closely associated with regard to media sampling and analysis, standard operating procedures, instrumentation, field work protocols and the integration of the ERA and the NRDA. This Plan will specifically reference the QAPP when detailed information is needed regarding constituents of potential concern, method numbers, laboratory methods, detection limits, etc.

The objectives of this Plan are to:

- 1) Summarize existing data related to the Site and Study Area;
- 2) Present the Site Conceptual Model for the Site and Study Area;
- 3) Outline the techniques and methodologies that will be used to identify and characterize the composition of the slag materials and potential transport during normal rain and flooding conditions;
- 4) Summarize the transport mechanisms, pathways, depositional areas for metals originating from the Site. Additionally, summarize all surface water discharge points into Joachim Creek within 1.5 miles upstream of the confluence with the Mississippi River;
- 5) Outline the techniques and methodologies that will be used to sample and analyze sediment, surface soils and surface water;
- 6) Outline the techniques and methodologies that will be used to generate a habitat map of Joachim Creek and the adjacent floodplain; and

- 7) Outline the techniques and methodologies that will be used to sample and analyze fish tissues from Joachim Creek and nearby in the Mississippi River.

### **1.1 Doe Run Lead Smelter Background**

The lead smelter has been operation for over 100 years and is the largest smelter of its kind in the United States. The smelter is an active lead smelting facility, currently owned and operated by Doe Run. The smelter is approximately 52 acres and consists of two main areas, the smelter plant and the slag pile storage area. The Site is bordered on the east by the Mississippi River, on the west and north-northwest by Joachim Creek, on the north by the lead smelter and residential areas, and on the south-southwest by Joachim Creek. A substantial portion of the Site is located in the floodplain wetlands of the Joachim Creek and Mississippi River.

#### **1.1.1 Slag Formation and the Slag Pile**

##### *1.1.1.1 Slag Formation*

When lead concentrate arrives at the smelter, it is dumped into a large feed hopper and mixed with fluxes and internally recycled lead-bearing materials such as baghouse fume. The resulting mixture is then tumbled to form pellets that are fed into the sinter machine. The sinter machine consists of a slowly moving grate that passes under a line of gas-fired burners. The lead concentrate pellets are layered onto the sinter machine grate with the bottom layer of pellets ignited by the gas burners. The combustion zone is slowly moved from the bottom to top by air pushed upward through the bed by large fans. The strong SO<sub>2</sub> gases are stripped of entrained dust and other impurities by an electrostatic precipitator and acid plant cleanup train then converted to commercial grade sulfuric acid in the acid plant. After the cakes of sinter are discharged from the sinter machine, the sinter is crushed and screened to a suitable size for the blast furnace (AOC).

Lead-bearing sinter is the main ingredient in the feed for the blast furnace. Sinter is mixed with coke and continuously fed through the tops of the blast furnaces. As the feed descends into the shaft of the furnace, it passes through blasts of hot air and gases. Carbon contained in the coke reacts with the hot air forming chemically reducing gases, reducing the sinter to molten lead. Flowing from the bottom of the blast furnace, the molten lead collects in special pots and is transferred after cooling to the drossing department. At the same time, molten slag composed of reduction by-products is tapped from the furnace, granulated and returned to the sinter department as feedstock. Approximately 80% of the slag produced is reused as feedstock. The remaining 20% is sent to the slag storage area.

##### *1.1.1.2 The Slag Pile*

The Site is, at various locations, approximately 40 to 50 feet high and covers about 24 acres. The majority of the visible slag is very fine material. The heavy metals within the slag include arsenic, cadmium, copper, lead, nickel, and zinc. According to Doe Run, the slag material contains approximately 12-14% zinc and 1.5-2.5% lead, among other constituents. In early 1999, Doe Run constructed a drainage diversion ditch along the north side of the Site to divert any runoff from the area north of the pile. However, runoff in the ditch eventually enters Joachim Creek, as does precipitation falling directly onto the Site. There are no protective barriers to stop erosion during flood or storm events of slag material into nearby rivers. The

Mississippi River and Joachim Creek bottomlands are periodically flooded as a result of snow melt and seasonal storms. Visual inspection of the slag pile perimeter did not indicate erosion of the slag pile.

A substantial portion of the Site is located in a special flood hazard area inundated by the 100-year flood. Aerial and ground view photographs of the Site taken by United States Fish and Wildlife Service (USFWS) personnel in March 1998 document flood waters of Joachim Creek in contact with the slag material. In 1993 during a major flood event, water reached several feet up the sides of the slag pile as a result of backup from the Mississippi River.

The slag material generated at the Herculaneum smelter is stored in a Metallic Minerals Waste Management Area that was permitted in 1992 under Missouri's Metallic Minerals Waste Management Act. According to the Missouri permit, the waste management area may occupy a total area of approximately 62 acres.

Sections 2, 3, 4, and 5 describe existing data, media sampling, fish tissue analysis and habitat characterization, respectively, related to the slag pile investigation.

### ***1.2 Slag Investigation Conceptual Strategy***

As described on Figure 2, the sampling activities of the slag investigation (SI) will be integrated with the ERA and the NRDA. This integrated, conceptual strategy is consistent with the general management approach outlined in the AOC. Because of the incomplete knowledge of the Site and the iterative nature of the SI, additional data requirements and analyses may be identified throughout the process. Establishing a conceptual strategy utilizing a Conceptual Site Model (CSM) and Data Quality Objectives (DQO) based approach at the beginning of the process, will serve to guide data collection activities toward the development of a common, comprehensive, end-point driven, risk management strategy for the Site.

The integrated SI, ERA and NRDA approach is based on a review of the historical data, the current condition of the Site, a preliminary CSM and the requirements set forth in the AOC. Recognizing that the investigative process typically follows an iterative path, a two-phased integrated approach was developed (Figure 2). A phased approach will efficiently fulfill data gaps identified during a review of existing physical, chemical and hydrogeologic data and Phase I and II investigation activities for both the baseline risk assessment (BRA) (refer to the ERA workplan) and NRDA.

SI investigative activities will be initiated following the approval of various workplans outlined in the AOC. Overall, the proposed phased approach includes filling data gaps to evaluate the "source-pathway-exposure" scenarios outlined in the preliminary CSM (Figure 3). At the completion of Phase I, a better understanding of area-specific as well as site-wide conditions will be developed in an effort to refine the preliminary CSM. Additionally, data gaps necessary to refine the CSM as part of Phase II will be identified.

### ***1.3 Conceptual Site Model (CSM)***

A preliminary CSM has been developed to illustrate preliminary interpretations of potential sources, pathways and exposure scenarios at the Site. The preliminary CSM, as shown on Figure 3, serves as the basis for the phased approach as conceptually described below. Ultimately, the CSM will serve as the basis for the BRA.

A CSM is defined as "a written description and visual representation of predicted relationships between receptors and the stressors (contaminants of potential concern) to which they may be exposed" (USEPA, 1997c and 1998b). The CSM is a very useful analysis and

communication tool for a BRA, and is typically presented in a schematic figure. It is used to describe the relationship between potential chemical sources, chemical release and transport mechanisms, locations of potentially exposed receptors, and potential exposure routes.

A CSM is also useful for identifying and communicating data gaps that can be addressed with additional sampling. For Phase I, a preliminary CSM has been developed from historical and preliminary data. This preliminary CSM should be thought of as a "working model". As the BRA data set is refined through the Phase II of the SI, the CSM will be refined with additional information regarding the sources of contaminants of potential concern (COPCs), and complete transport and exposure pathways. The CSM will also support the NRDA preassessment screen. The three key aspects of the CSM, chemical sources, transport pathways, and potential exposure pathways, are discussed below.

### **1.3.1 Potential Chemical Sources**

Sources are locations where COPCs are first introduced into the environment. The slag pile has been identified as the potential source of COPCs. Sources of COPCs will be identified on the basis of historical information and data collected from the SI, and will be described in the refined CSM at the end of Phase I. The sampling regime will also be developed to characterize other potential sources of COPCs with specific regard to runoff from the City of Herculaneum and the wastewater treatment plant outfall that discharges into Joachim Creek.

### **1.3.2 Potential Transport Pathways**

The evaluation of COPC transport pathways will involve three steps. First, the physical routes along which the COPCs may be transported will be identified. Second, the data from the SI samples will be reviewed for evidence that COPCs have been or are being transported along each physical pathway. Third, the general environmental transport and fate of the COPCs will be discussed, using appropriate modeling techniques if necessary, to evaluate if a COPC would be expected to be mobile in a physical pathway. The third step is most useful for evaluating pathways for which no data currently exist, and for evaluating hypothetical future exposures that involve predictions. Fate and transport modeling may also be useful for ground-truthing data and/or results. These three steps are further discussed below.

#### *1.3.2.1 Physical Transport Pathways*

The physical pathways at the Site through which COPCs may be transported include:

- Surface drainage pathways – ditches, culverts and tributaries;
- Volatilization from soil or water surfaces, or vertical migration from the subsurface;
- Wind-blown vapors, dust or soil;
- Subsurface flow conduits – infiltrated stormwater drains, and areas of porous fill; and
- Groundwater flow pathways – hydrogeologic gradients; porous media and seeps.

As shown in Figure 3, the preliminary potential transport pathways have been identified as surface water, soil, sediment, groundwater and ambient air as wind. As part of the SI, surface water, sediment, surface soil and groundwater will be fully characterized by a strategic sampling program to determine if these media are being used as transport pathways for COPCs from the Site.

### *1.3.2.2 Data Review*

Data from historic investigations and the SI will be reviewed to identify if there is evidence that COPCs are currently being, or have historically been transported along each downgradient pathway from each source. In general, the presence of a COPC in a downgradient area of a physical pathway suggests that it has migrated down that pathway. Not only must a COPC be present in the appropriate medium of a physical pathway, it must also be present at several places along the pathway. Moreover, a decreasing concentration gradient should be observed with distance from the source because the COPC concentration will tend to decrease as a result of dilution and/or degradation processes. Complete transport pathways for COPC transport will be identified in the CSM, as will incomplete pathways. Where data are equivocal, the following step will be conducted.

### *1.3.2.3 General Environmental Transport and Fate of the COPCs*

The environmental transport and fate of substances are controlled by a combination of two factors: the prevailing environmental conditions and the properties of the individual substance that influence partitioning and reaction tendencies (Mackay et al., 1995). Environmental transport and fate models may be used to describe the expected behavior of each COPC. Model selection will be based on the specific physical pathway under consideration. Site data will be compared with modeled data to check for congruence. When modeling is insufficient to evaluate if a pathway is complete, additional sampling may be proposed for the next phase of the investigation to address this data gap.

## **1.3.3 Potential Exposure Pathways**

As presented by USEPA (1989), the following four components are necessary for chemical exposure to occur:

- A chemical source and a mechanism of chemical release to the environment;
- An environmental transport medium for the released chemical;
- A point of contact between the contaminated medium and the receptor; and
- An exposure route at the exposure point.

Four of these elements must be present for an exposure pathway to be considered complete, and for chemical exposure to occur. If one or more of these elements is absent, then no potential for chemical exposure exists, and, consequently, there is no risk or hazard to potential receptors. In this case, no further evaluation would be necessary in the BRA (refer to the ERA workplan).

Based on the development of the CSM, three outcomes are possible for each potential source and transport pathway:

- One or more of the requirements for exposure is absent; therefore, the pathway is incomplete and there is no exposure;

- Four requirements for exposure are present, but the pathway is considered to contribute insignificantly to overall chemical exposures in relation to other contributing pathways; or
- The requirements for exposure are present, and the pathway is considered significant with respect to other contributing pathways.

Only those pathways in the last category are typically quantified in a risk assessment (USEPA, 1989). Pathways will be evaluated on a site-specific basis. The rationale for excluding pathways will be discussed in the BRA report. Moreover, other sources of chemical contamination will be identified and studied to make certain that COPCs are Site-related. The final CSM will include modifications to pathways and exposure points based on results of additional site characterization samples. Any changes to the preliminary CSM developed at the end of Phase I will be clearly presented and explained in the BRA report.

For a complete description of how the phase-approach and CSM relate to the ERA and the NRDA, refer to the ERA and NRDA workplans associated with the SI.

#### ***1.4 Objectives of the SI Field Program***

The Phase I SI field program has been developed to determine if 1) Site-related contaminants have impacted surface soils, sediments, surface water and groundwater on and adjacent to the Site, and, 2) if impacts are detected, investigate the nature and extent of contaminant impacts. The Phase I SI field program was developed to address the requirements set forth in the AOC for the Site and the objectives below:

- Determine which areas of the Site, if any, are contaminant source areas;
- If source areas are identified, characterize potential surface and subsurface contaminant pathways;
- Determine if contaminants are migrating from the source areas;
- Characterize the nature and extent of detected COPCs;
- Collect and analyze existing and additional data to refine preliminary CSMs that establish potential receptors and exposure pathways; and
- Quantify potential ecological risk and assess the potential for natural resource injury.

To address these objectives, this SAP was written to outline the sampling regime during Phase I. Phase I SI activities will include:

1. Review of existing data;
2. Sample collection and analysis of potentially affected media (surface water, surface soils, sediment and groundwater);
3. Describe the initial sampling strategy and methodologies that will be used to collect fish for the purposes of tissue analysis during Phase II of the SI, if warranted;
4. Performing habitat characterization and listed species surveys; and
5. Determining additional data requirements based upon the preliminary CSM and established DQOs. These activities will be initiated subsequent to the approval of various workplans outlined in the AOC.

Section 2 of this SAP describes the evaluation of existing data made available at the time of the writing of this report. As described in previous sections, the results of the data evaluation have largely contributed to the strategy behind the sampling regime outlined in this SAP as

well as have contributed to the identification of data gaps. Once Phase I data has been reviewed, the results of that evaluation will guide future sampling and analysis efforts (Phase II), if required.

Section 3 of this SAP outlines the strategies and protocols utilized to characterize potentially affected surface water, sediment and surface soils as a result of the historical and current operation of the Site. In addition, the techniques used to characterize slag materials from the Site are provided. To support the development and refinement of the CSM for the BRA and the NRDA, surface water and sediment samples will be collected from Joachim Creek, ephemeral ponds and surface water drainage pathways within the Study Area. Additionally, surface soils will be collected from the floodplain surrounding the slag pile. These data will be used to interpret potential sources, surface transport pathways, and exposure points with respect to the CSM. Any data gaps, with respect to the preliminary CSM, will be identified and used to develop the scope of Phase II investigations, where necessary. Information as to sampling methodology, sample location, sample analysis, quality control procedures and reference location rationale is included. The protocols used to characterize potentially affected soil from the City of Herculaneum and groundwater are described in the Community Soil Cleanup Plan and Groundwater Monitoring Plan under separate work plans.

The collection of freshwater fish for the purposes of tissue analysis, if required, during Phase II of the SI is described in Section 4 of the SAP. Specialize sampling and handling protocols are detailed. As described in Section 4, the collection of fish for tissue analysis, if required, will occur once Phase I of the SI is complete. Once the data is reviewed from the sampling of affected media (determining potential transport pathways), the screening-level ERA (refer to the ERA workplan) can proceed and the questions proposed in the preassessment screen of the NRDA can be answered (Figure 2). During Phase I, abundant habitat and fisheries data will be gathered during the Index of Biotic Integrity Survey. These data will contribute to developing the most technically sound, cost-effective sampling regime with regard to fish collection. It is crucial that transport pathways and target species be established and the list of COPCs be developed prior to the submission of fish tissues to the laboratory.

Finally, Section 5 of this SAP describes methods that will be utilized to perform a thorough habitat characterization of the Study Area, which will, in turn, contribute to development of the habitat map required as part of the AOC. This habitat characterization will also yield data that will aid in determining potential injury to natural resources under the NRDA. As previously mentioned, an Index of Biotic Integrity will be conducted on a study reach of Joachim Creek and a reference reach to compare fish populations in the vicinity of the Site. A quantitative floristic community survey will be performed along multiple transects in the Study Area and reference areas to show whether plant populations have been impacted by the operation of the Site. In addition, a qualitative threatened and endangered plant species survey and wetland delineation will be conducted in the Study Area to delineate sensitive habitats in the area of the Site.

## 2 Summary of Existing Data

Historical environmental data from the Site have been reviewed to determine the extent to which these data are suitable and appropriate for inclusion in the ERA. Historical data generally do not meet all of the requirements for risk assessment (USEPA 1989 and 1992c), however, they have been incorporated, where appropriate into the design of the preliminary CSM for this SAP. Key aspects of existing data that determine whether they are usable for risk assessment, as identified by the USEPA (1989) include:

- Sample locations that are explicitly identified;
- Use of appropriate analytical methods and detection limits;
- Data that have been validated using appropriate procedures; and
- Data that are representative of current conditions.

Data that do not meet all of these requirements will be eliminated from use in the screening-level and baseline ERAs. The existing data are briefly reviewed with respect to these parameters in the following subsections.

Numerous samples have been collected from the Site and Study Area during the past two decades. Samples have been collected by many different investigators, and for different purposes. The ambitious schedule in the AOC precluded a comprehensive review of every historic sample during the development of the required work plans. Therefore, this review of existing data focused on the three documents that contained the most comprehensive reviews of historic data from the Site and Study Area. These three review documents included:

Wiebler, B and Coffey, M. 1999. Preliminary Ecological Risk Assessment for Fish and Wildlife Habitats around the Doe Run Company Lead Smelter, Herculaneum, Missouri. U.S. Fish and Wildlife Service, Region 3 Contaminants Program, Rock Island, Illinois, Draft Report, February 11, 1999;

Wilder, V. 1999. *Preliminary Assessment Report: Herculaneum Lead Smelter Site, Jefferson County, Missouri*. Missouri Department of Natural Resources, Division of Environmental Quality, Hazardous Waste Program. March 30, 1999; and

Maxim Technologies Inc. 2000. *Final Herculaneum Slag Storage Area Groundwater Monitoring Program, 1999*. Maxim Technologies, Inc., St Louis, Missouri. April 2000.

These documents include relatively thorough reviews of historic data, which are not repeated here. However, the information in these documents has been used, where appropriate, in the development of this SAP. The primary use of existing data has been to develop a preliminary CSM. Specific limitations of existing data relative to screening-level and baseline ERAs are discussed below.

### 2.1 Not all Sample Locations are Explicitly Identified

There is a lack of consistency in the existing data with respect to descriptions of sample locations. The most consistent descriptions are for groundwater samples, which have been collected from wells that have been logged, mapped and named. This level of consistency is the result of a planned monitoring effort. Most of the other samples from the Site and Study Area have been collected in more of an opportunistic basis. As a result, there are large differences in the detail of sample descriptions and sample location maps. It is not clear if some samples that are described as "soil" or "sediment" are actually samples of slag that were collected during times when the floodplain of Joachim Creek was inundated. Residential soils

data are typically reported based on distance from the smelter rather than by an address or map coordinates. Other soils samples have more complete descriptions.

Fish have been collected from Joachim Creek and the Mississippi River. Mouse and bird tissues have been sampled from "various locations along the shoreline of Joachim Creek adjacent to the smelter facility." The exact locations of these samples are unknown. The exact location of surface water samples is very difficult to determine from existing maps and descriptions.

It is impossible to determine if the existing soil, sediment, or surface data represent a source, a transport pathway, or an exposure point. The existing data as a whole indicate there may be a source of one or more hazardous substances within the Site and Study Area, and that fish and wildlife might be exposed to hazardous substances, however, the pathways of transport and exposure have not been characterized. Consequently, the existing data are not suitable for a baseline ERA.

## ***2.2 Use of Appropriate Analytical Methods and Detection Limits***

There is little information regarding the specific analytical methods that were used for the historical data. As a result, it is not possible to determine if the methods used were consistent among the studies. Moreover, specific quality assurance/quality control (QA/QC) information regarding accuracy, precision, and consistency are not included in the review documents. It is uncertain if the historical data meet QA/QC requirements for baseline risk assessment.

Historical chemical analyses have emphasized a suite of the transition metals Cadmium, Copper, Lead, Nickel, Zinc, and sometimes Arsenic and Chromium. However, data regarding the full Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) Target Analyte List (TAL) for metals is not presented. Consequently, the existing data are not sufficient for a screening-level ERA for metals.

## ***2.3 Data Validation***

Specific QA/QC information regarding accuracy, precision, and consistency are not included in the review documents. It does not appear that data have been assigned qualifiers in accordance with data validation guidance (USEPA, 1989, 1992c, 1999b). Consequently, it is uncertain if the historical data meet data validation requirements for baseline risk assessment.

## ***2.4 Data are Representative of Current Conditions***

Metals are very stable in the environment because they are elements. Transition metals do not decompose in the environment, however, changes in environmental conditions will affect the long-term transport, fate and bioavailability of these metals. Consequently, environmental conditions will also influence the ecological risk posed by metals. For example, 10 mg/kg zinc sulfide ( $\text{ZnS}_2$ ) poses several orders of magnitude less risk than 10 mg/kg ionic zinc ( $\text{Zn}^{++}$ ), because only the zinc ion can reach the molecular site of toxic action. It appears that the existing data for the Site and Study Area are only available for total metal concentrations. As a result, there is very little information about the mobility or bioavailability of metals in the Site and Study Area.

Data from the elutriate test that was conducted by the USFWS in 1998 provide some limited information about the mobility of metals in the slag. For this test, 100 grams of slag were mixed with 200 mL of synthetic moderately hard water. After mixing for one hour, the slag-water elutriate was allowed to settle for 1.5 hours, then was used to conduct toxicity tests

with larval fathead minnows (*Pimephales promelas*). Chemical analyses were conducted on unwashed slag, and on the elutriate water at the end of the 96 hour test. These data allow the mass transfer of several metals from the slag to surface water to be estimated. The review documents listed above did not present an evaluation of metal mobility, therefore, a summary is provided in Table 2-1. Based on the slag and elutriate water data that are summarized in Table 2-1, it appears that very small fractions (0.0063% to 0.69%) of the metal mass in the slag are mobile in the environment. This preliminary estimate is based on a single sample, however, and is not adequate for assessing baseline ecological risks in the Study Area.

**Table 2-1. Preliminary Estimate of Metal Mobility in Slag from the Slag Storage Area.**  
Estimates were derived from Appendix A, Item I of Wiebler and Coffey, 1999.

METAL	MASS IN 100 GRAMS OF SLAG (MG)	MASS IN 200 ML OF ELUTRIATE WATER (MG)	FRACTION THAT DISSOLVED IN WATER (%)
Arsenic	2.8	No data	Insufficient data
Cadmium	3.2	0.022	0.69
Chromium	No data	<0.004	Insufficient data
Copper	320	0.032	0.010
Lead	2,300	0.14	0.0063
Nickel	14	0.030	0.21
Zinc	9,600	0.88	0.0092

The Mississippi River experienced a major flood in 1993, when the floodwaters throughout the valley reached 500-year flood levels. Many levees broke, and the floodplain topography was altered by scouring and sand deposition. The Missouri River experienced another large flood in 1995. Some of the existing data are from fish, water and sediment samples that were collected before these floods. These pre-flood samples are not likely to be representative of current conditions, and are not suitable for use in this ERA.

appropriately sampled. Transects along the depositional point bars within the creek are an appropriate means of characterizing sediments, and will be used for this investigation.

Figure 4 shows the proposed sediment sampling locations for Joachim Creek in the vicinity of the Site. For the purposes of this work plan, a total of seven (7) transect locations have been proposed. For each transect, 3 discrete sediment samples will be collected along depositional zones for a total of 21 sediment samples along the 1.5-mile study stretch of the creek. Sediment samples will be collected using the methods described in #99-0034-SOP-02 in Appendix A of this SAP.

No sediment samples are proposed for collection in the Mississippi River during Phase I, though one of the transect locations is placed at the confluence of Joachim Creek and the Mississippi River.

### **3.1.2 Sediment in Ephemeral Ponds and Drainage Pathways**

Ephemeral ponds in a floodplain river system act as surface water and sediment collection areas when the floodwaters recede. Therefore, these ponds will collect and concentrate the sediment wash load carried during a flood event. Many of these ephemeral ponds also may receive surface water drainage from the Site. Therefore, a minimum of two sediment samples will be collected for each drainage pathway/ephemeral pond pair that could potentially receive surface runoff from the Site or flood waters from the Mississippi River and Joachim Creek. One sample will be placed near the boundary of the Site, where constituents could enter the ephemeral pond/drainage pathway through a drainage pathway, and the other sample will be placed near the most likely depositional area (i.e., ephemeral pond). These are the locations where Site-related or river-related constituents would most likely accumulate, and therefore represent the most conservative approach for identifying transport pathways. The resulting data will be used to determine which transport pathways are complete for the purpose of developing the CSM. Pairing the samples in this way will also indicate if the pathway is directly linked to the Site or if the floodwaters of the Mississippi River or Joachim Creek provide a transport pathway for COPCs. If the later case is true, then samples collected from point bars in the reference and Study Area will help determine the potential source. If additional data are needed to complete the CSM, additional sampling efforts may be used in Phase II of the SI.

While on a site visit in November, 2000, ELM identified four potential drainage pathways, adjacent to the Site, along the bank of Joachim Creek within the 1.5-mile study reach. These four drainage pathways were also identified by USFWS personnel during previous observations at the Site. The USFWS has numbered each of the pathways as described in Table 3-1 and shown on Figure 4.

Table 3-1. Potential Drainage Pathways Identified by the USFWS and ELM.

USFWS DESIGNATION	LOCATION OF DRAINAGE PATHWAY	DESCRIPTION OF DRAINAGE PATHWAY
1	This discharge point is located approximately 1200 feet upstream of the confluence of Joachim Creek and the Mississippi River.	This discharge point appears to be an outfall from the wastewater treatment unit that is located adjacent to the slag pile to the east. The outfall is currently discharging directly from the bank and sits low on the slope. A culvert or discharge pipe was not visible at the time of the site visit due to trash, logs and leaves covering the outlet. When Joachim Creek is at a high flow condition, the outfall is submerged. At the time of the site visit, effluent was flowing from the outfall into Joachim Creek.
2	This drainage pathway is located approximately 1400 feet upstream of the confluence of Joachim Creek and the Mississippi River. Traveling upstream, the pathway meanders to the west and north where it eventually runs under the lead smelter. This pathway is located directly east of the wastewater treatment unit.	This drainage pathway is cut into the bank and potentially discharges run-off surface water from the City of Herculaneum roadways. At the time of the site visit, water was flowing from this drainage pathway into Joachim Creek.
3	This drainage pathway is located approximately 2500 feet upstream of the confluence of Joachim Creek and the Mississippi River. The pathway flows directly from the former borrow pit to the east and into Joachim Creek.	This drainage pathway is cut into the bank and originates from the emergent wetland and former borrow pit located directly south of the slag pile. At the time of the site visit, water was flowing from this drainage pathway into Joachim Creek.
4	This drainage pathway is located approximately 5000 feet upstream of the confluence of Joachim Creek and the Mississippi River.	Based on the condition of the drainage, it appears that flows only occur intermittently, probably during periods of heavy flooding or precipitation, or possibly when drainage pathway #3 is blocked. The drainage channel appears to be artificial and was probably cut into place when the borrow pit was in use. At the time of the site visit, water was not flowing from this drainage pathway into Joachim Creek.
Not Enumerated	This potential drainage pathway is located approximately 5500 feet upstream of the confluence of Joachim Creek and the Mississippi River and is located on the south toe of the slag pile, west of the former borrow pit. It lies upstream of Drainage Pathway #4.	The drainage pathway has not been characterized in the field, so a description of the habitat and flow regime has not been made.
Not Enumerated	This potential drainage pathway is located approximately 1200 feet upstream of the confluence of Joachim Creek and the Mississippi River and is located adjacent to the railroad bridge (along the upstream side) of Joachim Creek east of the lead smelter. It lies downstream of Drainage Pathway #1.	During a site visit in November, 2000, ELM observed that run-off from the parking, storage and railroad areas east of the lead smelter entered this cut in the west bank of Joachim Creek and entered the creek adjacent to the railroad bridge.

Two additional drainage pathways have been identified by aerial photography and site reconnaissance but have not been enumerated (Table 3-1). Currently, there are 12 sediment sampling locations proposed in the ephemeral ponds and drainage pathway habitats that have been identified to date (Figure 4). Ephemeral pond and drainage pathway sediment samples will be collected using the methods described in #99-0034-SOP-02 in Appendix A of this SAP.

### 3.1.3 Reference Sediment Sampling Locations and QA/QC

#### 3.1.3.1 Reference Sediment Sampling Locations

To establish the baseline conditions for the NRDA, to estimate incremental, "site-related" exposures for the ERA, and to measure the background concentrations of target analytes, Doe Run will collect sediment samples from the Joachim Creek watershed, ephemeral ponds and drainage pathways from locations that are upstream of the Site. These reference locations will represent similar habitat (substrate, flow, meanders, depth, etc) as that of Site and Study Area conditions. While on a site visit in November, 2000, ELM conducted a site review of several possible reference locations. Six locations, both within the Joachim Creek watershed and outside its watershed, were visually inspected to assess surrounding habitat, flow and substrate type. Only one of the six potential reference locations observed appeared somewhat similar to the lower Joachim Creek area in the vicinity of the Site (Table 3-2).

**Table 3-2. Potential Reference Locations Observed by ELM (November, 2000).**

WATER BODY	LOCATION	POTENTIAL REFERENCE SITE (YES OR NO)	REASON
Joachim Creek	Upstream of the small dam $\frac{3}{4}$ of a mile; east of the City of Herculanum; 600 feet west of State Highway 67/61	No	This area of Joachim Creek is much wider than the Study Area and there is much less flow
Joachim Creek	Approximately 2 rivers miles west of Interstate-55; 1000 feet west of Herky Festus Rd. along the Missouri-Pacific Railroad Line	No	This area of Joachim Creek is much wider than the Study Area and there is much less flow
Sandy Creek	Upstream of the intersection of Horine Rd. and Sandy Creek; 400 feet west of Interstate-55	No	More shallow than Study Area and less flow
Sandy Creek	Upstream of the intersection of Highway Z and Sandy Creek; 800 feet west of the Burlington Northern Railroad Line; north of the City of Horine	Yes	Substrate, width of stream, and flow similar to that of Study Area
Plattin Creek	Southeast of Crystal City, MO; upstream of the Burlington Northern Railroad Line; $\frac{3}{4}$ of a river mile west of the confluence of Plattin Creek and the Mississippi River	No	Substrate, width of stream and flow much different than Study Area
Glaize Creek	Confluence of Glaize Creek and the Mississippi River; south of Sulphur Springs, MO;	No	Stream width much smaller than Study Area; active borrow pit located adjacent to Glaize Creek contributing significant TSS loads; active petroleum storage tank farm adjacent to Glaize Creek with active outfall

As a result of this reference location reconnaissance, it is apparent that a thorough characterization of potential reference sites will need to be conducted prior to sampling to determine the most appropriate reference locations. Prior to reference sampling, a characterization of Joachim Creek and associated tributaries and similar ephemeral ponds/drainage pathways will be conducted to determine the most representative reference sites. It is possible that the most representative reference areas are outside of the Joachim Creek watershed. However, every effort will be made to remain close to the Herculaneum area. At a minimum, the reference sites selected will be located outside the influence of the operations of the lead smelter. Since the exact references have not been established, the total number of reference sediment samples is unknown. Once reference locations are established, site maps will be generated for agency approval.

### *3.1.3.2 QA/QC for Sediment Sampling*

The inclusion of quality control (QC) samples will be an important part of the sediment sampling regime for the SI. It is imperative that the concentrations of COPCs detected in the sediment after analysis represent actual sediment concentrations and not concentrations that are elevated because of contaminated sampling equipment or fugitive dust at the sampling location. Additionally, it is important to collect field duplicate samples to assure the laboratory is exercising an acceptable degree of accuracy and precision while conducting various analyses. Therefore, the frequency of QC samples that will be collected while sampling for sediment is described in Table 3-3.

**Table 3-3. Frequency of Collection for Quality Control Samples During Sediment Sampling.**

<b>SW-846 METHOD NUMBER</b>	<b>FIELD DUPLICATES</b>	<b>FIELD (AMBIENT) BLANKS</b>	<b>FIELD (RINSATE) BLANKS</b>
6010B	20%	NA	20%
7471A	20%	NA	20%
9060	10%	NA	NA
9081	10%	NA	NA
ASTM D422	10%	NA	NA

NA = Not Applicable

During sediment sampling, one (1) duplicate sample for every 10 investigative samples (10%) or two (2) duplicate samples for every 10 investigative samples (20%) will be collected depending upon what analysis is proposed. The same frequency of field rinsate (equipment) blanks will be collected depending upon what analysis is proposed. Field ambient blanks will not be collected during sediment sampling. Field ambient blanks will be collected during surface water sampling and sediment and surface water sampling is proposed to occur in tandem.

Field QA/QC measures are important to assure that all samples collected are valid for analysis. To that end, auditing procedures will be implemented during the collection of sediment for the SI. Each sampling crew will also be audited to ensure that the field SOP for collecting sediment (#99-0034-SOP-02 in Appendix A of this SAP) is followed. The audit check list and audit findings report forms are included in the SOPs. Each crew will be audited at the initiation of site work and then periodically, as deemed necessary by the QA Manager. If field auditing

results find that inconsistencies, cross-contamination and/or poor sampling methods are occurring the QA Manager will direct the sampling crews to cease all sample collection and the sample program will be thoroughly reviewed by Doe Run to initiate corrective action procedures.

#### 3.1.3.2.1 Field Documentation

In an effort to centralize and manage data and field activities as efficiently as possible, record of field activities will be collected in multiple ways. Field records to be maintained include:

- Calibration logs;
- Field logbooks;
- Sample collection/field data forms;
- Sample collection/field audit forms;
- QC sample logs;
- Photographic logs; and
- Chain of custody.

These forms and logbooks will track the sampling activities in way that ensures all QC performance criteria are met and that all data collected can be traced to its source location and is described appropriately. Each of these items will be filed by date in a secure location at the field site. Each one is further described below.

#### **Calibration Log**

For each electrometric field instrument proposed for this investigation a calibration log form has been devised. This will ensure that the field crew will calibrate each instrument at the specified frequency and that the results of each calibration will meet QC acceptance criteria.

#### **Field Logbook**

A hardbound "Rite-n-Rain" field logbook will be maintained by each field crew collecting data during this investigation. The field logbook will be used to provide a narrative of the moment to moment activities of the sampling crew. The field logbook will also be used to summarize all conversations (including phone calls) with members of the project management team.

#### **Sample Collection/Field Audit Forms**

Sample collection/field data forms are designed to collect all pertinent ancillary data for the sample media (e.g., water: pH, conductivity, temperature, DO, and Redox) and note the date, time, sample label identification, and any other observations made during sampling. The Sample Collection/Field Data Forms are located with each SOP in Appendix A of this SAP.

#### **Sample Collection/Field Audit Forms**

Sample collection/field audit forms are designed based on the QA/QC specifications listed in each field operation SOP. These forms are located with each field SOP in Appendix A of this SAP. Each field crew will be audited to ensure that all appropriate measures are taken to collect a quality sample. Sampling crews will be audited at the beginning of their sampling efforts and then periodically at the discretion of the QA Manager. The auditor will note any possible activities that may compromise a sample, and record these observations on the form.

#### **QC Sample Log**

The QC Sample Log will ensure that QC Samples (e.g., field duplicates, field ambient blanks, field rinsate blanks, trip blanks, and matrix spike/matrix spike duplicates) are collected at the appropriate frequency for each media and each analysis.

#### **Photographic Log**

The Photographic Log form will be used to note the time, date, and location of each photograph taken during the SI. A Photographic Log form is included with both the Surface Water and Sediment Sampling SOPs in Appendix A of this SAP.

### **Chain of Custody**

A Chain-of-Custody (COC) form will accompany all sample shipments to the laboratory. The sample ID's, date and time of collection, initials of sampling crew, analyses requested for each sample, and environmental matrix will be listed on the Chain-of-Custody form. The COC will also contain all the contact information for the laboratory that will be analyzing the samples and the contact information for the sampling crew who collected the samples. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents transfer of custody of samples from the sampler to another person, to a courier service, to a mobile laboratory, to the permanent laboratory, or to/from a secure storage area.

Detailed descriptions of each of these records are available in Section 1.5.1 of the QAPP and will not be made here. Please note that field documentation, as described in this section and in Section 1.5.1 of the QAPP, will be consistent with each type of media sampled. Therefore, all of these records will be completed, where applicable, for sediment, surface water, surface soils, slag, fish collection and sampling and habitat mapping procedures.

### **3.1.4 Sediment Sample Collection and Analysis**

#### **3.1.4.1 Sediment Collection**

Sediments tend to accumulate over time, with the surface layer representing current Study Area conditions. Surface sediments contain the potentially bioavailable fractions of the COPCs. Silt and especially clay particles tend to be strong adsorbers, since both have a high surface area per unit volume with significant electrical charges at the surface. High organic content in soil also lends to increased sorption capacity. Conversely, the constituents in subsurface sediments are chemically bound, and are not available to the ecosystem. Consequently, surface sediments are a pertinent medium for this Phase I investigation.

Sediment samples will be collected with a coring device whenever possible. Sediment core samples are preferred for quantitative analyses because the collection process is the most reliably reproduced across the Site in terms of sample surface area and depth. The sampling strategy will consist of targeting the top ten centimeters of sediments at each location, such as the silt and clay-filled depressions along the creek banks. Further, the top ten centimeters represent the zone most likely to contain biological receptors. In addition, multiple core samples at a particular layer will be collected and combined to produce a composite that has sufficient volume for chemical analyses. The core method of sample collection also will allow a field inspection of deep sediment layers. Therefore, if non-native material appears in the deep layers of the sediment, samples will be collected for laboratory analysis. Additional subsurface sediment sampling may be conducted in later phases if there are data gaps regarding the relationship between subsurface contamination and exposure to surface sediments. In summary, surficial sediment core samples are the most representative and reproducible means of collecting data for the ERA and NRDA, and will be the primary means of sediment sample collection. Alternate techniques may be used only if Study Area conditions prohibit sediment coring.

Sediment samples will be collected using a dual sampling scheme depending on the COPCs being analyzed. For inorganic analysis, only non-metallic sampling equipment will be used to

collect a sediment sample. The sampling apparatus consists of a core barrel composed of cellulose acetate butyrate, a plastic extruder, and plastic spatula.

For a complete description of sediment sampling collection methods for inorganic analysis, refer to #99-0034-SOP-02 located in Appendix A of this SAP.

#### *3.1.4.2 Sediment Analysis*

The focus of this investigation will be the assessment of metals and environmental parameters that affect their fate, transport, and toxicity (cation exchange capacity, pH, and Redox).

As shown in Table 3-4, specific sediment samples from Joachim Creek, ephemeral ponds and drainage pathways will be analyzed for the following constituents using the following methods:

**Table 3-4. Laboratory Analysis and Method Number Associated with Sediment Characterization.**

<b>LABORATORY ANALYSIS</b>	<b>SW-846 METHOD NUMBER</b>
Metals (except Hg)	6010B/3050B
Mercury	7471A
Total Organic Carbon	9060
Cation Exchange Capacity	9081
Particle Size Distribution (PSD)	ASTM D422

In summary, a total of 33 investigative sediment samples have been selected for these analyses (Figure 4). A total of 21 samples will be submitted from Joachim Creek and 12 will be submitted from ephemeral pond/drainage pathways.

A complete list of constituents to be analyzed, laboratory and analytical method numbers, laboratory SOPs, detection limits, preservation, holding times and collection device information can be found in the QAPP associated with the SI and this SAP.

### **3.2 Surface Water Sampling Strategy**

To fulfill the requirements described in the AOC and to support the ERA and NRDA, surface water samples will be collected and paired with sediment samples, whenever possible. This approach will provide a more comprehensive assessment of Site and Study Area conditions than either a sediment-only or water-only sampling program. The lower end of Joachim Creek flows adjacent to the Site prior to its confluence with the Mississippi River. The target areas for surface water sampling will consist primarily of potential source areas along the Site in conjunction with storm water and wastewater effluent outfalls into Joachim Creek. Transects for sediment sampling will be established along point bars of the creek to characterize depositional zones (Section 3.1.1). Similarly, transects for surface water collection will be established in the same area as these depositional zones. Portions of the Site are periodically flooded, and surface water will typically accumulate in ephemeral ponds in the Joachim Creek floodplain. Some of these ephemeral ponds are connected to the Site by surficial drainage

pathways. Surface water will be collected from these ephemeral ponds and drainage pathways to thoroughly characterize these pathways. Each strategy is discussed below.

### **3.2.1 Surface Water in Joachim Creek**

A site visit by ELM during November, 2000 was conducted to identify drainage pathways and become familiar with Site conditions. As a result of this site visit, a sampling transect approach will be utilized for surface water sampling in conjunction with sediment sampling. A transect will be established in the area of point bars that are sampled for sediment (Section 3.0). For the purposes of this work plan, a total of seven (7) sampling transects have been proposed. For each transect, three (3) discreet grab surface water samples will be collected for a total 21 samples. If site conditions are such that more than 6 transects are necessary, additional samples will be collected and updated maps showing sampling locations will be generated. One sample will be collected at the thalweg (the area of the water column where the deepest point lies) and the other two will be collect equidistant between the thalweg and the banks of Joachim Creek. The sample will be collected in the center of the water column at these three locations of the transect.

Figure 4 shows the proposed surface water sampling transects for Joachim Creek in the vicinity of the Site. These locations are for discussion purposes only. Exact locations for collection will be made in the field after the characterization of Joachim Creek. Joachim Creek surface water samples will be collected using the methods described in #99-0034-SOP-01 in Appendix A of this SAP.

### **3.2.2 Surface Water in Ephemeral Ponds and Drainage Pathways**

Ephemeral ponds in a floodplain river system act as surface water and sediment sinks when the flood recedes. Therefore, these ponds will collect and concentrate surface waters from the Mississippi River and Joachim Creek carried during a flood event. Many of these ephemeral ponds also may receive surface water drainage from the Site. Therefore, a minimum of two surface water samples will be collected for each drainage pathway/ephemeral pond pair that could potentially receive surface runoff from the Site or flood waters from the Mississippi River and Joachim Creek. One sample will be placed near the boundary of the Site, where constituents could enter the feature through a drainage pathway, and the other sample will be placed near the most likely depositional area (i.e., ephemeral pond). These are the locations where Site-related or river-related constituents would most likely be transported by surface flows, and therefore represent the most conservative approach for identifying transport pathways. The resulting data will be used to determine which transport pathways are complete for the purpose of developing the CSM. Pairing the samples in this way will also indicate if the pathway is directly linked to the Site or if the flood waters of the Mississippi River and Joachim Creek provide a transport pathway for COPCs. If the later case is true, then samples collected from surface waters in the reference and Study Area will help determine the potential source. If additional data are needed to complete the CSM, additional sampling efforts may be used in Phase II of the SI.

While on a site visit in November, 2000, ELM identified four potential drainage pathways along the bank of Joachim Creek that is adjacent to the Site within the 1.5 mile study reach. These four drainage pathways were also identified by USFWS personnel during various investigations at the Site that they have conducted in the past. These enumerated drainage pathways are described in Table 3-1. Also, two potential drainage pathways have been identified by aerial photography and site reconnaissance but have not been enumerated (Table 3-1).

Additionally, during the site visit, there was a steady rain falling in the Herculaneum, Missouri area. As a result, ELM identified several small drainage pathways immediately upstream of and adjacent to the railroad bridge located on Joachim Creek downstream of the Site. The pathways were discharging run-off water from the roadway on the east side of the property. These small pathways would be difficult to sample, even during a steady rain. However, every effort will be made to identify and sample any of these drainage pathways originating from the roadway to characterize the influence of run-off, if any, from the Site to Joachim Creek.

Currently, there are 12 surface water sampling locations proposed in the ephemeral ponds and drainage pathway habitats that have been identified to date (Figure 4). Ephemeral pond and drainage pathway surface water samples will be collected using the methods described in #99-0034-SOP-01 in Appendix A of this SAP.

### **3.2.3 Reference Surface Water Sampling Locations and QA/QC**

#### *3.2.3.1 Reference Surface Water Sampling Locations*

To establish the baseline conditions for the NRDA, to estimate incremental, "site-related" exposures for the ERA, and to measure the background concentrations of COPCs, Doe Run will collect surface water samples from reference locations. These reference locations will represent similar habitat (substrate, flow, meanders, depth, etc) as that of the Study Area conditions. While on a site visit in November, 2000, ELM conducted a site review of several possible reference locations. Six locations, both within the Joachim Creek watershed and outside its watershed, were visually inspected to assess surrounding habitat, flow and substrate type. Only one of the six potential reference locations observed appeared somewhat similar to the lower Joachim Creek area in the vicinity of the Site (Table 3-2).

As a result of this reference location reconnaissance, it is apparent that a thorough characterization of potential reference sites will need to be conducted prior to sampling to find the most appropriate reference locations. Prior to reference sampling, a characterization of Joachim Creek and associated tributaries and similar ephemeral ponds/drainage pathways will be conducted to determine the most representative reference sites. It is possible that the most representative reference areas are outside of the Joachim Creek watershed. However, every effort will be made to remain in the vicinity of the Herculaneum area. At a minimum, the reference sites selected will be located outside the influence of the operations of the lead smelter. Since the exact references have not been established, the total number of reference surface water samples is unknown. Once reference locations are established, site maps will be generated for agency approval.

#### *3.2.3.2 QA/QC for Surface Water Sampling*

The inclusion of QC samples will be an important part of the surface water sampling regime for the SI. It is imperative that the concentrations of COPCs detected in surface water after analysis represent actual surface water concentrations and not concentrations that are elevated because of contaminated sampling equipment or fugitive dust at the sampling location. Additionally, it is important to collect field duplicate samples to assure the laboratory is exercising an acceptable degree of accuracy and precision while conducting various analyses. Therefore, the frequency of QC samples that will be collected while sampling for surface water is described in Table 3-5.

**Table 3-5. Frequency of Collection for Quality Control Samples During Surface Water Sampling.**

<b>SW-846 METHOD NUMBER</b>	<b>FIELD DUPLICATES</b>	<b>FIELD (AMBIENT) BLANKS</b>	<b>FIELD (RINSATE) BLANKS</b>
6010B	20%	10%	10%
7471A	20%	10%	10%
Hardness-130.2	10%	NA	NA
Alkalinity-310.1	10%	NA	NA
TSS-160.2	10%	NA	NA

NA = Not Applicable

During surface water sampling, one (1) duplicate sample for every 10 investigative samples (10%) or two (2) duplicate samples for every 10 investigative samples (20%) will be collected depending upon what analysis is proposed. Field ambient blanks and field rinsate (equipment) blanks will be collected at one (1) for every 10 investigative samples (10%).

Field QA/QC measures are important to assure that all samples collected are valid for analysis. To that end, auditing procedures will be implemented during the collection of surface water for the SI. Each sampling crew will also be audited to ensure that the field SOP for collecting surface water (#99-0034-SOP-01 in Appendix A of this SAP) is followed. The audit check list and audit findings report forms are included in the SOPs. Each crew will be audited at the initiation of site work and then periodically, as deemed necessary by the QA Manager. If field auditing results find that inconsistencies, cross-contamination and/or poor sampling methods are occurring the QA Manager will direct the sampling crews to cease all sample collection and the sample program will be thoroughly reviewed by Doe Run to initiate corrective action procedures.

### **3.2.4 Surface Water Sample Collection and Analysis**

#### *3.2.4.1 Surface Water Sample Collection*

Prior to collecting surface water samples, ancillary data will be collected to complement analytical data. As shown on the field data sheet, the temperature, pH, conductivity, dissolved oxygen, Redox potential and flow of the water will be field screened. Ambient air temperature and weather conditions will also be noted. Table 3-6 lists the type of instrument and all QC information that is associated with the collection of ancillary data during surface water sampling:

**Table 3-6. Ancillary Field Measurement Information.**

<b>Field Parameter</b>	<b>Instrument /Equipment</b>	<b>QC Measures</b>	<b>Calibration Frequency</b>	<b>Acceptance Criteria</b>	<b>Corrective Action</b>	<b>SOP Number</b>	<b>Decon Procedures</b>
pH	Accumet	Field Duplicate, freq. of 10%	Beginning of each work day/freq. of 10% thereafter	Slope=90-102%	Re-calibrate/ Change buffers/ Replace KCL sol'n	99-0034-SOP-10	Rinse thoroughly with DI water

Conductivity	Orion Probe	Field Duplicate, freq. of 10%	Beginning of each work day/freq. of 10% thereafter	Criteria hard-wired into system; "E-22" error message	Adjust cell constant; clean conductivity cell; return to factory	99-0034-SOP-11	Rinse thoroughly with DI water
Dissolved Oxygen	Orion	Field Duplicate, freq. of 10%	Beginning of each work day/freq. of 10% thereafter	Criteria hard-wired into system; "E-3" error message	Clean sensor and replace membrane and electrolyte	99-0034-SOP-08	Rinse thoroughly with DI water
Redox	Orion Probe	Field Duplicate, freq. of 10%	Beginning of each work day/freq. of 10% thereafter	Suspect data	Clean electrode and replace electrode solution; return to factory	99-0034-SOP-13	Rinse thoroughly with DI water
Flow	TBD	TBD	TBD	TBD	TBD	TBD	TBD

TBD=To Be Determined

The instruction manuals from the manufacturer for the ancillary field equipment are included as Appendix L in the QAPP associated with the SI.

A simple sampling technique will be employed for the collection of water samples. Analytically-clean sample bottles will be immersed into the sample water, uncapped, allowed to fill, re-capped, and removed from the water body. The investigator will then remove the cap and allow the water to pour out of the vessel downstream of the sampling location. The investigator will repeat this process three times. On the fourth iteration, the investigator fills the vessel with sample water and properly stores the vessel until shipment. If the sample vessel includes a preservative, then a surrogate vessel will be filled with sample water and emptied three times as described above. On the fourth iteration, the surrogate vessel will be filled with sample water and then the sample water will be transferred to the vessel with preservative. The investigator should avoid leaving headspace (air bubbles) in the sample vessel as well as avoid stirring the sediments while collecting the sample. Artifacts from the sediment should not be included with the surface water sample. This procedure avoids cross-contamination among samples because only the dedicated sample bottle contacts the sample.

It is possible that the sampling crew may find that a particular drainage pathway exhibits little to no flow. If this is the case, the sampling crew will attempt to dig a small hole in the sediment to create a reservoir. The sampler dons clean, non-talc, PVC gloves and digs a hole wide and deep enough to fit a sample bottle. Once the reservoir is complete, the sampler may return the next day to determine whether a sample can be collected when submerging the sample vessels. The sampler must be aware that sediments are "stirred-up" very easy when attempting to retrieve a sample in this fashion. This not the preferred technique to collect the sample but is useful when a drainage pathway yields little flow.

The investigator should be aware of the type of personal protective and sampling equipment used during the collection of samples. While collecting samples for inorganic analysis, only plastic bottles should be used as sample vessels. Additionally, only non-talc, PVC (or equivalent) gloves should be worn while sampling. The QAPP, associated with this project, details the types of QC protocols that should be used while collecting surface water samples. The SOP for collecting surface water samples for inorganic (#99-0034-SOP-01) analysis detail the appropriate sampling equipment to be utilized in the field (Appendix A of this SAP).

Surface water sampling will be scheduled to correspond with worst-case exposure scenarios. Samples will be collected in the center of the water column between the water surface and the

sediment (or zone of mixing) particularly in Joachim Creek. Ephemeral ponds and drainage pathways will be sampled in early spring, when they contain water that has traveled across the Site. These samples will be scheduled before spring floods, if possible, to avoid dilution. The permanent water bodies will be sampled during mid-summer or early fall when the water levels and flows are lowest. This schedule will also minimize potential dilution. In addition to drainage pathways, streams and standing water bodies, groundwater seeps may also be sampled to evaluate potential subsurface transport pathways associated with groundwater.

For a detailed description of the sampling equipment, methodologies and data sheets used during surface water sampling, refer to SOP #99-0034-SOP-01 in Appendix A of this SAP.

#### **3.2.4.2 Surface Water Sample Analysis**

The focus of this investigation will be the assessment of metals and environmental parameters that affect their fate, transport, and toxicity (cation exchange capacity, pH, and Redox).

As shown in Table 3-7, surface water samples from Joachim Creek, ephemeral ponds and drainage pathways will be analyzed for the following constituents using the following methods:

**Table 3-7. Laboratory Analysis and Method Number Associated with Surface Water Characterization.**

<b>LABORATORY ANALYSIS</b>	<b>SW-846 METHOD NUMBER</b>
Total Metals (except Hg)	6010B/3015 (6020B/3020A)*
Dissolved Metals (except Hg)	6010B (6020)*
Total Mercury	7470A
Dissolved Mercury	7470A
Total Suspended Solids	160.2
Hardness	130.2/3010A
Alkalinity	310.2

In summary, a total of 33 investigative surface water samples have been selected for these analyses (Figure 4). A total of 21 samples will be submitted from Joachim Creek and 12 will be submitted from ephemeral pond/drainage pathways.

A complete list of constituents to be analyzed, laboratory and analytical method numbers, laboratory SOPs, detection limits, preservation, holding times and collection device information can be found in the QAPP associated with the SI.

### **3.3 Surface Soil Sampling Strategy**

According to the AOC, Doe Run is to "identify and characterize the transport mechanisms, pathways, and deposition areas for metals originating from the slag pile." Therefore, a sampling scheme has been developed to determine whether slag is migrating from the slag

pile and, if so, is it migrating and entering Joachim Creek. Much like the transect approach described for sediment and surface water sampling (Sections 3.1 and 3.2), a transect sampling approach has been proposed to determine if surface soils surrounding the Site receive runoff slag during rain and flooding events. To date, no study has been conducted to determine how much slag, if any, migrates off the slag pile and is deposited on the surrounding soil. The transect approach will characterize the surface soils in the vicinity of the Site to determine whether metals and/or other constituents are deposited on surface soils. Because of the proximity of the Site to Joachim Creek, the possibility exists that as floodwaters rise over the banks of Joachim Creek and flow downstream, slag materials could come into contact with this flowing water, be carried off of the pile and be deposited elsewhere. As described in Section 1.1.1, floodwaters have been visually observed coming into contact with the Site by the USFWS. Because of the potential for flooding to deposit slag materials to the surrounding floodplain, only surface soil shall be collected during Phase I of the SI. For the purposes of this project, surface soils include the 0-3 inch interval. If data indicate that COPCs have integrated the surface soils beyond a 3-inch depth, deeper soil samples may be proposed in Phase II of the SI.

As shown on Figure 4, six (6) sampling transects have been established around the Site. Along each transect, five (5) separate sampling locations will be sampled yielding a total number of 30 surface soil samples. Each sampling location along the transect will be established at progressively greater distances from the Slag. The first location will be five (5) feet off of the toe of the slag pile. The second location will be 10 feet from the first location. The third location will be 20 feet from the second location. The fourth location will be 40 feet from the third location. Finally, the fifth location will be 80 feet from the fourth location. The total length of the transect will be 155 feet. In summary, each of the five (5) surface soil sampling locations is twice the distance away from the slag pile as the last location (5'-10'-20'-40'-80'=155'). The data from these samples will be used to indicate whether COPCs migrate offsite and, if so, are deposited in the soil surrounding the Site.

The six (6) sampling transects have been strategically placed to capture possible offsite deposition of COPCs (Figure 4). One transect has been placed on the west side of the Site. To characterize potential migration from the southern slope of the pile, three transect have been proposed. Additionally, two transects have been proposed in the area of the former borrow pit adjacent to the southeast side of the Site. If, after a characterization of the area, additional or longer transects are required, they will be added in Phase II of the SI.

### **3.3.1 Reference Surface Soil Sampling Locations and QA/QC**

#### *3.3.1.1 Reference Surface Soil Sampling Locations*

To establish the baseline conditions for the NRDA, to estimate incremental, "site-related" exposures for the ERA, and to measure the background concentrations of target analytes, Doe Run will collect surface soil samples from reference locations. These reference locations will represent similar habitat (past and current land use, regional geology, etc) as that of the Study Area conditions. While on a site visit in November, 2000, ELM observed several possible reference locations as well as viewed historical aerial photographs of the area. Two possible reference locations were identified as shown on Figure 4. One reference location is within the "Future Waste Management Area" owned by Doe Run. It is located northwest of the Site, across Joachim Creek, within the floodplain. The second reference location is east of the Site, across Joachim Creek, within the floodplain and southwest of the railroad tracks. Both of these locations are within the floodplain of Joachim Creek, have similar past and current land use as the Study Area, and have similar geological and hydrogeological features. The

reference samples will be collected in the same manner as investigative samples to remain consistent. A sampling transect of 155 feet will be established and five (5) locations will be selected along the transect just as investigative locations (Section 3.3). Therefore, a total of 10 reference surface soil samples will be collected. A reference surface soil sample will be collected at five (5) feet, 10', 20', 40' and 80' along the transect. The exact location of the reference surface soil sampling transects will be made in the field so that site-specific conditions can be taken into consideration. Additionally, to remain as representative as possible, the reference locations will be established at the relatively same elevation as that of the investigative transects. By sampling reference and investigative locations that have the same elevation, the effects of flooding on these areas can assumed to be relatively similar. The protocols for collecting reference surface soil samples are described in SOP #99-0034-SOP-12 and in Section 3.3.2.1 of this SAP.

### *3.3.1.2 QA/QC for Surface Soil Sampling*

The inclusion of QC samples will be an important part of the surface soil sampling regime for the SI. It is imperative that the concentrations of COPCs detected in the surface soils after analysis represent actual surface soil concentrations and not concentrations that are elevated because of contaminated sampling equipment or fugitive dust at the sampling location. Additionally, it is important to collect field duplicate samples to assure the laboratory is exercising an acceptable degree of accuracy and precision while conducting various analyses. Therefore, the frequency of QC samples that will be collected while sampling for surface soil is described in Table 3-8.

**Table 3-8. Frequency of Collection for Quality Control Samples During Surface Soil Sampling.**

<b>SW-846 METHOD NUMBER</b>	<b>FIELD DUPLICATES</b>	<b>FIELD (AMBIENT) BLANKS</b>	<b>FIELD (RINSATE) BLANKS</b>
6010B	20%	10%	10%
7471A	20%	10%	10%
9081	10%	NA	NA
9045C	10%	NA	NA

NA = Not Applicable

During surface soil sampling, one (1) duplicate sample for every 10 investigative samples (10%) or two (2) duplicate samples for every 10 investigative samples (20%) will be collected depending upon what analysis is proposed. Additionally, one (1) field ambient blank and one (1) field rinsate (equipment) blank will be collected for every 10 investigative samples (10%).

Field QA/QC measures are important to assure that all samples collected are valid for analysis. To that end, auditing procedures will be implemented during the collection of surface soils for the SI. Each sampling crew will also be audited to ensure that the field SOP for collecting surface soils (#99-0034-SOP-12 in Appendix A of this SAP) is followed. The audit check list and audit findings report forms are included in the SOP. Each crew will be audited at the initiation of site work and then periodically, as deemed necessary by the QA Manager. If field auditing results find that inconsistencies, cross-contamination and/or poor sampling methods are occurring the QA Manager will direct the sampling crews to cease all sample collection and

the sample program will be thoroughly reviewed by Doe Run to initiate corrective action procedures.

### **3.3.2 Surface Soil Sample Collection and Analysis**

#### *3.3.2.1 Surface Soil Sample Collection*

As discussed at the beginning of Section 3.3, surface soils will be collected along a transect where one terminating end begins at the toe of the Site (Figure 4). When the investigators arrive at the sampling location, a transect location should be chosen. The investigators should then flag the discreet sampling locations at 5', 10', 20', 40' and 80' off of the toe of the slag pile. The sample labels should then be completed. The investigators will don only disposable, non-talc, PVC (or equivalent) gloves and retrieve the sample container. It is crucial that the investigators match the appropriate sample container and equipment with the type of analysis being conducted. For example, if inorganic analysis is to be conducted, only plastic vessels and plastic scoops/trowels should be used to collect soil. This procedure will decrease the chances of cross-contamination via equipment composition.

The investigators prepare the sample location by removing overlying debris (leaves, sticks, stones) to expose the underlying soil. The samplers will not sample an area that has been tracked-upon by either vehicle or foot. The sampler unearths the soil to a depth of not to exceed 3 inches with the appropriate scoop/trowel and place the soil sample into the specified sample jar. The sampler will immediately place the lid on the jar and wipe the excess material from the outside of the jar. The sample jar will then be placed into a plastic bubble-wrap bag and into a cooler with ice for storage. The samples will be recorded on a chain-of-custody form and placed into the cooler. The cooler of samples will be packaged and shipped to the laboratory using shipper specifications. A field data form for surface soil sampling will be completed by the investigators to document field conditions and soil descriptions. For a complete description of the protocols utilized during collect surface soil sampling, refer to SOP #99-0034-SOP-12 in Appendix A of this SAP.

#### *3.3.2.2 Surface Soil Sample Analysis*

As shown on Table 3-9, soil samples for the area surrounding the slag pile will be analyzed for the following constituents using the following methods:

**Table 3-9. Laboratory Analysis and Method Number Associated with Surface Soil Characterization.**

<b>LABORATORY ANALYSIS</b>	<b>METHOD NUMBER</b>
Total Metals (except Hg)	6010B/3050B
Total Mercury	7471A
pH	9045C
Cation Exchange Capacity	9081

All 30 investigative surface soil samples and the 10 reference samples will be submitted for the laboratory analysis listed on Table 3-9.

### ***3.4 Slag Pile Characterization***

The three principal pathways for transport of COPCs from the Site are through air, surface water, and groundwater. Since the alluvial aquifer under the Site is contained within a meander loop of a stream channel (Joachim Creek), it is likely that the stream plays a significant role in controlling groundwater within the meander loop by acting as sink or discharge region for groundwater. Consequently, the two dominant pathways that may transport slag constituents off site are through the air and surface water with groundwater acting as a conduit to surface water.

Inspection of the Site by ELM in November, 2000 provided significant indications of the Site influence on surrounding environment that might not be as evident during the spring and summer. For example, based on the heavy vegetation evident along the toe and adjacent to the Site (emergent wetland-Figure 8), the alluvium surface would be well drained and not hold standing water for prolonged time periods during the spring and summer growing season. However, during the site visit, a large but shallow borrow area adjacent to the Site that is heavily vegetated was filled with several inches of water that appeared to originate from upwelling groundwater adjacent to the toe of the Site (Figure 5). Large amounts of iron precipitate coating the flooded vegetation was evident in a broad band ( $\pm 100$  ft wide) adjacent to the toe of the Site.

A roadway cut from the top of the Site down to the flood plain appeared to be eroded and a principle source of local slag sediment. Sediment along the toe of the Site elsewhere was more difficult to find. The general lack of surface erosion was also an evident feature of the Site. Normally, erosion on large waste piles with sediment like characteristics is significant unless the waste materials are sufficiently coarse to possess relatively high infiltration rates. The lack of significant erosion was evident on most of the outslopes of the Site (Figure 6). This is likely due to the high infiltration capacity of the slag material and the limited slope lengths. Some rill erosion is evident in places, but the rill development is limited and generally does not appear to be active.

The presence of hydrophytic vegetation such as willows are evidence that while the surface of the alluvium is sufficiently drained to support grasses during growing season, an elevated local watertable is also likely present during the growing season. A concern that seasonally saturated surface conditions present is that upwelling groundwater from the Site results in precipitating iron from the groundwater, which accumulates at the surface. The precipitates appeared to be predominately ferric hydroxides that can be expected to contain trace metals such as lead and cadmium. The precipitates can then be removed by surface water and carried from the Site as sediment, colloidal material, or redissolved into solution in the surface water. Drainage pathways, as the one pictured in Figure 7, is an example of how precipitates could be potentially carried by surface water.

Based on the observations of upwelling groundwater around the base of the Site, it is reasonable to assume that a well developed groundwater mound is maintained within the Site. Given the coarse sand like characteristics of the slag material it is reasonable to expect that high infiltration of precipitation into the slag will continue to maintain a groundwater mound.

Fine slag material may be removed from the surface of the pile by wind erosion. The surface of the pile appears to be lightly armored in most places by a veneer of coarse slag material. At this time, it is not clear to what extent wind erosion may play in removal of fine material as compared with water erosion during precipitation events.

The processes discussed above are mechanisms that provide for possible transport of COPCs from the Site. In order to determine the rate of transport from the Site by the various mechanisms, detailed information about the characteristics of the slag material are required. Descriptions of how the slag material will be characterized are detailed in the sections following.

### **3.4.1 Slag Composition**

The process that produced the slag is assumed to have been relatively uniform over time. The chemical/mineral composition and particle size distributions (PSDs) of the slag material are assumed to be spatially distributed in a relatively uniform manner, as well. Reworking of the surface of the pile by various forces may have resulted in minor changes to the PSDs with fines removed from the surface of the pile by erosion over time. However, subsurface PSDs within the Site should remain unchanged. Consequently, sampling of the surface and near surface of the pile should provide unbiased samples that may be considered representative of the entire Site.

It is not known if there are differences in slag mineral composition as a function of particle size. In consideration of these factors, sampling of the pile will be conducted on the basis of surface character. The Site will be subdivided into three different types of areas: (1) the active dump areas where the surface is reworked by equipment or receives freshly dumped slag; (2) roadway areas where drainage may discharge off of the pile; and (3) side slopes where the surfaces have been affected by wind and water erosion.

The characteristics of the surface materials are important because they are materials that are immediately available for erosion by wind or water. The steep side slopes of the Site appear to be at the angle of repose and, consequently, excessive surface erosion would logically be expected from such surfaces. However, after examination of the side slopes it appears that surface erosion by water is minimal in most areas. In areas where water erosion by rilling is evident, the majority of the rills do not appear to be active. The top of the Site is relatively flat and there does not appear to be any areas where water accumulates by ponding for extended time periods. It appears that infiltration rates for the slag material may be relatively high accounting for the lack of erosion on side slopes and lack of ponding on flat surfaces. In the roadway areas where traffic mixes and abrades the slag material, particle size is probably reduced and the potential for retention of water likely is increased. Smaller particle size and water retention probably contribute to greater erosion off of the roadways.

### **3.4.2 Slag Pile Sampling Protocol**

As described in Section 3.4.1, the slag pile will be sampled in three different areas. Sampling in each of the areas will follow a different sampling protocol.

#### ***3.4.2.1 Freshly Dumped or Reworked Slag Materials***

The freshly dumped or reworked slag materials located on the active surface of the pile are expected to have a relatively uniform distribution of particle size. Slag material that is being dumped on the flat surface of the top of the pile would be expected to experience minor sorting of material at the base of exposed slopes, but the accumulation of courser materials at the toe of such slopes is expected to be minor and not significant enough to impact the sampling protocol of the slag materials. Grab samples of the slag material will be collected by scraping away the immediate surface materials and filling sampling containers with slag. As shown in Figure 4, a total of six (6) slag samples will be collected from freshly dumped or

reworked areas. Exact sampling locations will be determined in the field prior to sampling to account for site-specific conditions.

#### *3.4.2.2 Side Slopes*

Two types of samples will be collected from side slopes. The first type of sample will be of the very near surface of the side slope and the second sample type will be collected from six inches or more beneath the surface. The intent of the surface sample is to provide information about the PSD of surface materials in order to determine the size of materials that might provide surface protection by armoring the surface of the pile, and to estimate sediment yield off of the surface. The second sample will provide information about the nature of the material that was stored in the past as well provide insight into the nature of slag material that was eroded from the site by wind or water in the past. As shown on Figure 4, a total of nine (9) side slag pile sampling locations are labeled. Nine (9) surface samples and nine (9) subsurface samples will be collected from these locations yielding 18 discrete slag samples. Exact sampling locations will be determined in the field prior to sampling to account for site-specific conditions.

#### *3.4.2.3 Roadway Areas*

The material from the surface of the roadway will be sampled by collecting grab samples of loose or muddy materials located on the roadway surface. As shown on Figure 4, a total of three (3) roadway samples will be collected to characterizing areas where vehicles operate on the Site. Exact sampling locations will be determined in the field prior to sampling to account for site-specific conditions.

In addition to the three areas described in Sections 3.4.2.1-3.4.2.3, deep subsurface samples will also be collected from two continuously sampled boreholes located on the top of the slag pile. Detailed physical descriptions of the slag material will be made from the continuous sampler, and samples collected for analytical testing. Three (3) slag samples will be collected from each borehole yielding a total of six subsurface samples (Figure 4). Exact sampling locations will be determined in the field prior to sampling to account for site-specific conditions.

### **3.4.3 Analysis of Slag Characteristics**

The sampling program for the Site should consist of three elements:

- sampling of slag materials to determine the physical characteristics;
- determining the hydraulic characteristics; and,
- determining the chemical characteristics.

#### *3.4.3.1 Determination of Slag Physical Characteristics*

PSD of the samples will be determined by a standard method (ASTM D 422), which includes a sieve analysis and hydrometer test. Materials segregated by size during the sieve tests may be retained for chemical analysis of each size fraction to determine if there are significant chemical differences as a function of particle size. The hydrometer test is important primarily to determine the size distribution of the fine fraction (<0.074 mm) of the slag material. Understanding the size distribution of the very fine material is important as this material is

likely the size fraction that releases the greatest amount of metals into both surface and groundwater. For a full description of the method for PSD, refer to the QAPP associated with the SI.

### 3.4.3.2 Chemical Analysis of Slag

The chemical analysis of slag will comprise two areas: (1) metal speciation; (2) traditional total metals analysis; (3) other inorganic analyses.

In order to assess the primary distribution of metal species of metals in the slag material, samples will be analyzed by X-ray diffraction techniques. The majority of minerals occur in crystal form when conditions of formation are favorable. X-ray diffraction is a method of determining atomic and molecular structures by measuring patterns of scattered x-rays after they pass through a crystalline substance. A better understanding of the mineral composition of the slag samples will allow for a proper assessment of risk posed by the groundwater and surface water flowpath from the site based on the mobility of the components of the slag. In order to estimate how mobile the metals may be, x-ray diffraction analysis will be conducted on the different size particles to determine if there is any chemical bias based on particle size. X-ray diffraction analysis to be performed on fraction of slag samples < 74 µm and > 74 µm (**NOTE:** 74µm is "cutoff" of #200 sieve. Size fractions of sample to be determined **prior** to any grinding).

Each slag sample will also be submitted for total metals analysis using SW-846 Method 6020B/3050B.

In addition to metal speciation and metal analysis, slag samples will be analyzed for mercury, x-ray defraction, and paste pH. The pH of the slag materials will be determined by standard soil paste pH methods. Table 3-10 describes the laboratory analysis and associated method numbers that are proposed for slag samples.

**Table 3-10. Laboratory Analysis, Proposed Laboratory and Method Number Associated with Slag Characterization.**

LABORATORY ANALYSIS	PROPOSED LABORATORY	METHOD NUMBER
Metals (except Hg)	EN CHEM	6010B/3050B
Mercury	EN CHEM	7471A
X-ray Defraction	Colorado School of Mines	Refer to Appendix G of the QAPP
Total Metals	Colorado School of Mines	Refer to Appendix G of the QAPP
PSD	Colorado School of Mines	Refer to Appendix G of the QAPP
pH	Colorado School of Mines	Refer to Appendix G of the QAPP

For a description of each of these analyses, refer to the QAPP associated with the SI.

### 3.4.3.3 QA/QC for Slag Sampling

As described in Section 3.1.3.2, QC samples will be an important part of the sampling regime for the SI. The frequency of QC samples that will be collected while sampling for slag is described in Table 3-11.

**Table 3-11. Frequency of Collection for Quality Control Samples During Slag Sampling.**

<b>METHOD</b>	<b>FIELD DUPLICATES</b>	<b>FIELD (AMBIENT) BLANKS</b>	<b>FIELD (RINSATE) BLANKS</b>
6010B	20%	NA	20%
7471A	20%	NA	20%
pH	10%	NA	NA
X-ray Defraction	20%	NA	10%
PSD	10%	NA	NA

NA = Not Applicable

During slag sampling, 1 duplicate sample for every 10 (10%) investigative samples or 2 duplicate samples for every 10 (20%) investigative samples will be collected depending upon what analysis is proposed. One field rinsate (equipment) blank for every 10 (10%) investigative samples will be collected, and no field ambient blank will be collected during slag sampling. In addition, at one surface slag sample location and at one deep, subsurface slag sample location, four replicate samples will be collected for a total of 5 slag samples at those locations. Replicate samples will be collected to characterize the uniformity of slag materials at various depth intervals. The determination of where these QC samples will be collected will be made in the field at the time of sampling.

Field QA/QC measures are important to assure that all samples collected are valid for analysis. To that end, auditing procedures will be implemented during the collection of slag for the SI. Each sampling crew will also be audited to ensure that the field SOP for collecting slag (#99-0034-SOP-09 in Appendix A of this SAP) is followed. The audit check list and audit findings report forms are included in the SOP. Each crew will be audited at the initiation of site work and then periodically, as deemed necessary by the QA Manager.

### **3.4.4 Slag Pile Erosion Monitoring**

Systematic monitoring of the floodplain surrounding the slag pile, for the purpose of mapping possible depositional areas, requires an understanding of the probable nature of flood events before a detailed monitoring plan is developed. Once the probable nature of flooding is better understood, a detailed monitoring plan can be developed and implemented. In general, there will be two basic types of monitoring that will take place. The first type of monitoring is post flood event monitoring that will involve examination of predetermined monitoring points in the floodway. The second type of monitoring will involve monitoring during actual flood events. The detailed design of each type of monitoring will be completed after a detailed review of hydraulic/hydrology of the local Joachim Creek/Mississippi River area and flood sequence history.

#### *3.4.4.1 Dynamics of Tributary/River Hydrology*

Monitoring of tributaries in the vicinity of the streams that receive them, for purposes of understanding flows over floodplains, can be complex because the hydrographs of the respective streams will likely be out of phase with each other. A local storm with significant

run off may well cause Joachim Creek to rapidly rise to flood level without having a significant impact on Mississippi River water levels. Conversely, a second class of events would be flooding on the Mississippi River which will likely occur slowly and last for extended periods of time. A third type of occurrence is one or more flood events occurring on Joachim Creek during an extended Mississippi River flood event.

A stream like Joachim Creek consists of a series of related topographic structures such as floodways, terraces, pools, riffles, and sand bars that reflect the long term behavior of the stream as a system. The shape or form of the stream channel and associated floodplain with one or more terraces provide insight into how the stream generally behaves during flooding. The general features of the stream system include the primary channel, primary terrace or floodway, secondary and tertiary terraces or floodplain. Each of these major features may contain some of the structures mentioned above.

The primary channel is the portion of the stream system within which the waters of the stream usually flow during non-floods. The primary channels usually develop with a capacity (bankfull) to pass the runoff from storm events that statistically occur every one or two years. The primary channel typically is equivalent to bank full in upland settings removed from the influence of receiving streams. In the vicinity of receiving streams, it is common for tributary channels to be more deeply incised to levels reflecting receiving stream base flow levels. However, the floodplain elevation of the tributary close to the receiving stream reflects the elevation of the receiving stream. This is especially true if the receiving stream is much larger than the tributary.

The primary terrace or floodway includes the first areas flooded once floodwaters exceed bank full stage. Generally the primary terrace is bound by a second elevated bank that rise up to the rest of the floodplain. The shape or form of the primary terrace depends on the hydraulic characteristics of the watershed, including soil type and slope of the valley. Near the junction of tributaries to receiving streams, especially where the receiving stream is much larger than the tributary, the primary terrace may appear to be absent, intermittent, or will be contained within the channel. In the case of Joachim Creek near the Mississippi River, the primary terrace is intermittent to absent, and insignificant.

The secondary and tertiary terraces normally make up the majority of the floodplain. These upper terraces develop over time as successive flood events cover the floodplain and deposit progressively finer sediments. In mature well developed floodplains such as along Joachim Creek, relatively thick sequences of finer grained sediments indicate that the floodplain is mature and is only occasionally flooded (due to flooding of Joachim Creek alone) compared to primary terraces. The major role of mature floodplains is storage of floodwater rather than acting as a significant floodway, especially near the confluence of tributaries with large receiving streams.

The role of the receiving stream is important to the behavior of tributaries such as Joachim Creek because the water level or flood stage of the receiving stream has a strong influence on the flow characteristics of overbank flows on the floodplain.

The primary channel of Joachim Creek near its confluence with the Mississippi River is overfit compared to the channel and it's characteristics upstream of the Mississippi River influence. The creek channel cross section near the river probably developed in response to normal high water on the river during the spring. Because the high water in the river creates a backwater condition in the creek, the creek develops a larger cross section to handle the normal flow of the creek. However, because the elevated river stage is generally seasonal, the creek will spend part of the year readjusting the channel floor each year seeking equilibrium with the rivers normal or low flow condition. This process is what causes an enlarged or overfit channel to develop near the confluence of a tributary with a large receiving stream. The result is that near the confluence of a large receiving stream, the primary channel of the tributary has a

greater capability to pass a flood event when the receiving stream is at normal or low flow. During receiving stream high water conditions, flood events in the tributary watershed is more likely to cause inundation of the floodplain due to backwater influence.

During low water conditions on large receiving streams, extreme flood events on the tributaries can also cause overbank flows across flood plains close to the receiving streams. These events are the floods that are most likely to have significant water velocities across the floodplain and may have the greatest potential for causing erosion. Backwater flooding of the tributary floodplain induced by the receiving stream (all or in part) would not be expected to cause erosion on secondary or tertiary terraces of the floodplain.

#### 3.4.4.1.1 Joachim Creek Characteristics

Joachim Creek floodplain near the confluence with the Mississippi exhibits the features discussed above. The features are more or less present depending upon the distance up stream of the actual confluence with the Mississippi River. Locations very close to the confluence exhibit few features other than a deeply incised overfit channel traversing the Mississippi River floodplain that is closely bound by bedrock valley margins.

Upstream of the confluence of Joachim Creek and the Mississippi River near the slag pile, stream and floodplain features are more developed. The primary channel is still overfit and in the process of degrading the channel by removing sediments deposited during extended periods of river backwater conditions of the last several years between 1993 and 2000. The primary terrace features are ephemeral being limited in size and contained within the overfit primary channel, and currently are being degraded. Secondary and tertiary terraces are present on the floodplain. The secondary terrace is relatively narrow and adjacent to the primary channel typically only two to three feet lower than the tertiary terrace. Immediately adjacent to the channel, natural levees, commonly and frequently breached, are present. Vegetation on the secondary terrace is thick and likely significantly influence velocity of overbank flows. Some evidence of local scour is also evident here within the secondary terrace as are areas of deposition.

The tertiary terrace dominates the floodplain in the vicinity of the slag pile. The floodplain consists of the inside of a large meander loop of Joachim Creek that is for the most part incised into bedrock and is consequently bound on both extremes by steep valley walls. The tertiary terrace is heavily vegetated with no evidence of scour or erosion that would be associated with rapidly moving water from Joachim Creek. Consequently, there are no indirect indicators of what actual water velocities there are over the majority of the floodplain. Based on a site review of conditions on the floodplain, it appears that primary role of the meander loop floodplain is for storage of floodwater. Since the portion of the floodplain occupied by the slag pile also appears to be affected by backwater from the Mississippi River, it provides floodwater storage for the river as well.

#### *3.4.4.2 Preliminary Data Needs*

Successful short term monitoring of the Joachim Creek floodplain is dependent upon two factors. First is the nature of weather and runoff in the Mississippi River basin and Joachim Creek watershed during the monitoring period. Second is appropriate design of a monitoring plan. The second factor is influenced by the nature of flood flows across the floodplain. In order to understand how floodwaters are likely to behave during the monitoring events so that an appropriate design can be detailed, different sized flood events will need to be simulated

under different receiving stream conditions. The goal of the simulations is to determine probable events during the monitoring period as well as estimate conditions required for an event that is most likely to result in erosion of the slag pile. Once the nature of Joachim Creek flood events are better understood, then a specific monitoring plan can be finalized and implemented.

#### 3.4.4.2.1 Flood Simulations

Computer based simulations provide flood routing information for a simulated rainfall event. The simulations are sensitive to accurate inputs such as soil conditions or factors, slope, stream channel conditions, and characteristics of storm events. In order to simulate an event in a watershed, the watershed is divided into smaller subwatersheds and the flows are routed to an outlet or endpoint. Within each subwatershed, conditions are averaged. Consequently, flood events that include overbank flows still use one algorithm that predicts flows within the channel as well as floodplain. Some models provide better computational methods for accounting for flows over floodplains than other models, but no single model seem to have all of the ideal features. Since the specific issue presented here is determining what the probable flows will be over the floodplain near the slag pile, the focus of the modeling should be on determining the nature of a flood event delivered to the floodplain. Different models will be examined to determine which model appears to provide the best information that will allow determining a reasonable floodwater surface profile across the floodplain. The profile will be used to estimate velocities and flow directions at different points on the floodplain taking into account natural features. These final estimates, and the monitoring described above, will be used to establish a specific monitoring plan. Candidate models include models such as the U.S. Army Corps of Engineers HEC-5 model to simulate and route flood flows on Joachim Creek and the USGS FEQUTL model to examine floodwater profiles and velocities as cross sections perpendicular to the creek and across the floodplain.

#### *3.4.4.3 Preliminary Approach for Floodplain and Slag Pile Monitoring*

A preliminary approach for floodplain and slag pile monitoring is presented below. The approach described below will be finalized after the preliminary data needs described in Section 3.4.4.2 are fulfilled.

The major issue in developing a floodplain and slag pile monitoring plan sufficient to provide data to estimate potential slag pile erosion and scour, is where monitoring should take place and if it should be an automated system or be comprised of manual measurements made at predetermined stations. If possible, manual measurements will be made. The decision to rely on a manual measurement system will depend upon the probable flood stage at the site for probable storms, the preferred monitoring locations, and the safety associated with conducting measurements under the anticipated conditions.

Monitoring of potential erosion and scour will involve two general types of observations. The first is water velocities as a function of depth and position relative to the slag pile. The second will be observation of wave action against the sides of the slag pile and documentation of the slag removal by wave action.

#### 3.4.4.3.1 Water Velocity Measurements

Manually monitoring water velocities in the floodplain would be conducted at predetermined locations along the edge of the slag pile. There would be a minimum of five profile locations established along the edge of the slag pile. At each location a survey line will be established perpendicular to the side of the slag pile. The survey line will, at a minimum, be 100 feet long. The survey line will be marked by embedding two poles in the ground. One pole will be located at the far end of the line from the slag pile, the other pole will be located approximately 15 feet from the edge of the slag pile. Both poles will be marked with surveyed elevations between which a line may be drawn taut against which to make measurements. Depending upon the magnitude or stage of a flood event two to five measurements at various depths are made at four or more locations along the line between the two poles. A minimum of five measurement points are used between the near pole and the side of the slag pile. Measurements will be made with a current meter, with a record made of the flow indicators (such as clicks or beeps), and all of the meter settings. The flow indicator data will be converted to water velocities and velocity profiles developed.

One flood stage recorder (continuous recorder) will be established in the near vicinity of the slag pile. The location will be such that it will record the full stage of Joachim Creek as well as that on the floodplain.

#### 3.4.4.3.2 Wave Action Measurements

The role of wave action on potential erosion of the slag pile will be documented by establishing a minimum of three profiles along the base of the slag piles after the characteristics of the probable flood events are understood. Erosion and scour of the slag pile will be measured by determining the change in the benchmark profiles after flood events. Benchmark profiles will consist of a length of the slag slope beginning at the base and extending a distance up the slope corresponding to above the expected high water mark. A tensioned wire will be strung between the rods just above the surface of the slag pile slope. The profiles will then be documented photographically and by measurements made between the wire and slag surface at uniform distances along the wire. The erosion can then be calculated from the difference between beginning and ending measurements.

Based on the apparent PSD of the slag material it is reasonable to expect near downslope deposition of slag as wave action erodes the slope creating narrow beach like features. If velocities of the floodwater parallel to the slag pile are not significant then the majority of the eroded slag material should appear downslope of the beach cut as slump like features. If the floodwater velocities are significant, the slag material will tend to be distributed in a band away from the side of the slag pile. During flood events, the potential wave action erosion of the slag would likely be noticeable as a dark turbid band adjacent to the shoreline since the slag material is darker than the buff colored sediments that appear to be dominate in the watershed. If significant floodwater velocities are present, then the dark turbid slag laden water will be expected to develop a plume leading in the flow direction. Water samples of the slag laden water can be collected and the solids content determined, but the results would not be expected to provide useful data representing actual quantities of slag removed from the pile. However, any area covered by slag sediment plumes would provide a footprint within which the majority of slag sediments would be deposited. After flood events these areas could be examined to determine if any slag materials were discernable.

Measurement and sampling protocols for each location will be developed after the specific equipment, technique, and locations, have been determined.

### ***3.5 Summary of Media Sampling***

In summary, to compile with the requirements described in the AOC, Doe Run will collect sediment, surface water and surface soil samples from the Study Area and representative reference locations (Sections 3.1, 3.2 and 3.3). Additionally, multiple slag samples will be collected to complete a full characterization of slag materials (Section 3.4). The following table (Table 3-12) outlines the proposed number of samples to be collected per matrix and the proposed sampling location for each sample.

Table 3-12. Summary of Media Sampling for the Slag Investigation.

Matrix	Sample Type	Number of Investigative Samples	Sample Location*
Sediment	Transects in Joachim Creek	7 transects X 3 discreet samples = 21	(Transect 1) - immediately upstream of the dam; (Transect 2) - immediately downstream of the dam; (Transect 3) - along the southwest toe of the slag pile; (Transect 4) - along the southeast toe of the slag pile; (Transect 5) - adjacent to the wastewater treatment unit; (Transect 6) - downstream of the bridge on the east side of the smelter; (Transect 7) - the confluence of Joachim Creek and the Mississippi River
	Ephemeral Pond/Drainage Pathways in floodplain	12	Drainage Pathway #1, #2, #3 and #4 are located between the toe of the slag pile and the confluence of the Mississippi River and Joachim (represents 7 of the 12 sediment samples);
			One potential drainage pathway not enumerated is located at the southeast toe of the slag pile (represents 2 of the 12 sediment/surface water locations)
			One potential drainage pathway not enumerated is located adjacent to the railroad bridge downstream of Drainage Pathway #1 (represents 1 of the 12 sediment/surface water locations)
			Two sediment samples are proposed on the upper portion (west side) of the former borrow pit adjacent to the east toe of the slag pile (represents 2 of the 12 sediment/surface water locations)
Surface Water	Transects in Joachim Creek	7 transects X 3 discreet samples = 21	Refer to sample locations for transects in Joachim Creek for sediment in this table
	Ephemeral Pond/Drainage Pathways in floodplain	12	Refer to sample locations for ephemeral pond/drainage pathway for sediment in this table
Slag	Freshly Dumped	6	In areas where slag has been recently been deposited or moved-to be determined in the field
	Side Slopes	9	There are multiple side slopes with the slag pile-to be determined in the field
	Roadways	3	Along the roadways used when driving in and out of the slag pile storage area
	Subsurface	2 boreholes X 3 discreet samples = 6	To be determined in the field
Surface Soil	Transect in the floodplain	6 transects X 5 discreet samples = 30	(Transect 1) - northwest side of the slag pile between the pile and Joachim Creek; (Transect 2) - southwest side of the slag pile between the pile and Joachim Creek; (Transect 3) - southern toe of the slag pile between the pile and Joachim Creek; (Transect 4) - southeast side of the slag pile between the pile and Joachim Creek; (Transect 5) - southeast side of the slag pile between within the former borrow pit; (Transect 6) - southeast side of the slag pile between within the former borrow pit

\* Exact sample locations will be made in the field prior to sampling to account for site-specific conditions. All proposed sampling locations on Figure 4 are approximate.

## 4 Fish Sampling and Analysis

To address the requirements described in the AOC and to determine potential exposures to natural resources, fish will be collected at selected locations in Joachim Creek and the nearby Mississippi River for the purposes of tissue analysis. Over the past several years, USFWS personnel have monitored habitat quality along the Mississippi River as part of their trustee responsibilities. The results of these monitoring activities indicated that elevated concentrations of metal COPCs were observed in the Middle Mississippi River and in Joachim Creek around the confluence of these two waterways. (south of the City of St. Louis, Jefferson County, Missouri) (USFWS, 1999).

As described in the ERA plan, one assessment endpoint has already been chosen for the SI as specified in the AOC. This endpoint is fish populations. Because assessment endpoints are typically not chosen until Step 3 of the 8 step DQO process, Doe Run will not be addressing this assessment endpoint until the completion of Phase I data collection and the screen level-ERA. Specifically, the AOC specifies that Doe Run estimate risk posed to the ecosystem and injury to fish through chemical analyses of whole and fish fillets. Therefore, measurement endpoints have also been identified by the AOC. However, in the interest of meeting USEPA guidance requirements, a specific study design for addressing contaminant residues in fish tissue will not be devised until:

1. The COPCs have been identified;
2. The fate, transport and effects of COPCs have been discussed; and
3. The fish community in the Study Area has been characterized (IBI).

### 4.1 Fish Sampling Strategy

The fish sampling strategy, for the purpose of tissue analysis, will be driven by the phased-approach outlined in the ERA, NRDA and this SAP. Both the ERA and NRDA follow a phased-approach which allows the sampling regime to occur in the most efficient manner possible. It is important that the collection of fish follow this phased approach so that unnecessary field sampling and analysis efforts are not expended and that the investigation is focused.

During the screening-level ERA, as described in the ERA plan, the list of COPCs are derived so that the investigator knows which constituents are present at elevated concentrations in the affected media. Surface water, surface soil, sediment and groundwater in the area of the Site are submitted for the full scan of target analytes which provides a comprehensive starting point for the beginning of the data reduction process (see ERA plan), which results in the COPC list. As part of the data reduction process the ecological risk assessor will determine whether the detected constituents are present at concentrations that may yield adverse effects. If the literature support such a result, then fish tissues from the affected waters in the area of the Site will be submitted to the laboratory for analysis for those COPCs.

This phased-approach is also evident during the preassessment screen of the NRDA. To determine whether unpermitted releases of hazardous substances have occurred or if trust resources have been potentially injured, these resources are submitted to the laboratory for analysis. First, environmental media (surface water, soil, etc.) are analyzed for all target analytes to determine the COPC list. This also shows which potential pathway may be significant for a Trust resource. Then, if affected media show that receptors are potentially exposed to concentrations that may cause adverse affects, then tissues are submitted for analysis.

Another important aspect of the phase-approach in the NRDA is the determination of baseline. Baseline, in the NRDA process, refers to the quality of Trust resources before the release of oil or hazardous substances. Therefore, during the analysis of fish tissue, the collection of fish in reference locations will become crucial in determining if elevated levels of Site-related constituents (if any) originated from the Site. If tissue analysis is conducted during this investigation, comparisons will be made of the fish caught adjacent to the Site in Joachim Creek to those caught outside the influence of the slag pile.

## **4.2 Fish Collection**

Fish collection methods will be largely based on Missouri Department of Conservation (MDC) and USEPA protocols where applicable (MDC, 2001 and USEPA, 2000). Because, in Phase II, the fish collected for this investigation will be submitted for tissue analysis, the sampling protocols and QC requirements become more stringent. Therefore, it will be important that the sampling team follow the guidelines outlined in the aforementioned documents as well as the SOP associated with fish collection and subsequent tissue analysis for this project (#99-0034-SOP-03 in Appendix A of this SAP).

Fish will be collected using electrofishing techniques (backpack shockers and boat shocking) and seine nets. During the Index of Biotic Integrity (IBI) survey proposed for this project, a thorough habitat characterization will be conducted on Joachim Creek prior to the start of the survey. Once the IBI is complete in Phase I, data will be available to determine the more appropriate locations in the study area for fish tissue analysis. Results from the IBI will also indicate what species of fish are present so that the most ecologically-relevant species will be collected and submitted for analysis. In addition to investigative sampling locations, a thorough review of potential reference areas will be made. The reference areas chosen will be those that have similar habitat characteristics of the investigative sample locations, and the reference locations will be located outside the influence of the operations of the smelter.

Once the sample locations (both investigative and reference) have been determined after a review of IBI data, the most appropriate time of year to sample will be selected. Sampling times will be based on the biology and natural history of the fish species of choice (i.e., migratory patterns, habitat of preference, forage base, etc). The MDC recommends sampling fish between 1 June and 15 September when stream flows are generally low, contaminant stress is potentially the greatest and the fish community is most stable and sedentary (MDC, 2001).

When sampling locations and the appropriate time of year to sample have been determined, the sampling crew mobilizes for fish collection. As mentioned in Section 4.1, the screening-level ERA and the preassessment screen of the NRDA will have occurred prior to sampling for fish for the purposes of fish analysis. The results of these screening processes will indicate the COPCs that pose a potential risk to ecological receptors. It is important to have an understanding of the COPCs because they will determine the composition of various pieces of sampling equipment used during fish collection. For example, metallic measuring boards, scales and calipers should not be used to process fish being submitted to the laboratory for metals analysis when metals are the primary COPCs. The type of decontamination media also plays an important role in quality control matters. Alconox or equivalent type of detergent typically works well to decontaminate sampling gear. However, prior to collection, the sample crew should ask the laboratory what media is acceptable to decontaminate equipment.

The sampling crew electroshocks or uses a seine net to collect fish as described in #99-0034-SOP-03. The fish are collected into buckets or holding trays until processing occurs. Once a sufficient amount of the desired species is collected, the sampling crew chooses an area on the bank to begin processing. The sampling crew will collect data such as the number of fish

being submitted for analysis, lengths, weights, sex, and incidence of external anomalies for each species as indicated by the "Field Record for Fish Contaminant Monitoring Program" data sheet associate with #99-0034-SOP-03 in Appendix A of this SAP. When the processing of fish is complete, the fish being submitted for analysis will be placed in the appropriate container that will not contribute to cross-contamination. A sample identification label will be completed and taped to the outside of each double "zip-lock" bag. The chain of custody tag will be completed and attached to the outside of the double "zip-lock" bag with string or tape. Once bagged correctly, samples will be cooled on ice immediately. Samples will be packed and shipped as described in #99-0034-SOP-03.

### **4.3 Fish Analysis**

As discussed in Section 4.1, the COPCs have not been determined to date. Once all media that is collected during Phase I of the SI is submitted for laboratory analysis, the list of COPCs can be generated. It is at this time that fish from Joachim Creek and nearby in the Mississippi River will be collected and submitted for analysis, as required. The fish tissue will be analyzed for those COPCs that have been found to be present in environmental media. Upon completion of Phase I of the SI, Doe Run will submit an Addendum to this SAP, which will include the following information:

- Potential locations for fish collection (both investigative and reference);
- Ecologically-relevant fish species to be collected and submitted for analyses;
- Revised SOP (if appropriate) for collecting fish for the purposes of fish tissue analysis (#99-0034-SOP-03);
- Quantity of fish tissue (both whole fish and fish fillet) required by the laboratory to complete all analyses;
- Laboratory analyses and method numbers for which fish tissue will be submitted; and
- Timeline for fish collection and analyses.

In addition to the Addendum to this SAP, an Addendum will also be written for the QAPP, which will outline specific laboratory methods, QC protocols, detection limits and other laboratory-related information.

## 5 Habitat Mapping

To determine the baseline ecological conditions of the Site and Study Area and determine if injury has occurred to natural resources as a result of Site-related activities, a complete habitat map will be generated. The habitat map will include Joachim Creek and all areas between Joachim Creek and Doe Run's property up to 1.5 miles upstream of the confluence with the Mississippi River. The following field surveys and methodologies are proposed to generate a thorough habitat map:

- Index of Biotic Integrity;
- Quantitative Floristic Community Survey;
- Qualitative Threatened and Endangered Plant Species Survey; and
- Wetland Delineation.

The following subsections describe each of the above methodologies and how each will be applied within the Study Area.

### 5.1 Index of Biotic Integrity

Ecological indices for aquatic habitats are typically based on water chemistry, macroinvertebrate communities or fish communities. Water quality indices are usually used to determine if a particular water body has potential to support biological organisms, or a public water supply. The macroinvertebrate and fish indices typically are used to evaluate the degree of impairment in a water body. The Macroinvertebrate Biotic Index (MBI) and the Index of Biotic Integrity (IBI) are two examples. Because both the MBI and the IBI evaluate the degree of impairment to a water body, their applicability would be useful during Phase I of the NRDA process. However, because of the lack of habitat for benthic invertebrates (root mats, fallen trees, logs, undercut banks, etc) and the dynamic sandy substrate at the lower end of the Joachim Creek, it is the opinion of ELM biologists that a MBI conducted in this particular stretch of the creek would not yield sufficient quantifiable data to compare reference and study reaches. Therefore, no MBI will be conducted. It is believed that an IBI conducted on Joachim Creek using applicable Missouri and/or Illinois Environmental Protection Agency (IEPA) protocols or area specific methodologies (i.e., backpack shocking or boat shocking specific habitats using consistent manpower and time limits) using IBI techniques would yield comparable data between any chosen study or reference reach. The decision to how to apply the IBI protocols will be made in the field by experienced fisheries biologists during low flow conditions. The decision to choose a particular reference or study reach is strictly based on habitat comparability of the two reaches. Ideally, the creek will exhibit low flow conditions to properly evaluate the habit of the potential reach and the surrounding area.

Currently, the MDC and the MDNR are developing Missouri-specific fish sampling methods. The sampling techniques under development evolved from a statewide bioassessment program that would establish a baseline of current conditions of Missouri's aquatic resources and allow the MDC to determine the effectiveness of the management programs and seriousness of environmental threats. As a result of the need to establish this "baseline of current conditions", the concept of Resource Assessment and Monitoring (RAM) was conceived. To achieve RAM goals and objectives, the MDC, along with the MDNR, developed a draft Standard Operating Procedure manual for the fish sampling component of MDC's RAM program. Because the MDC manual is in draft form during the writing of this SAP, general IBI protocols are proposed as described in IEPA, 1994. Methods described in the MDC manual will be employed where applicable.

Fish occupy upper levels of aquatic food chains and are directly and indirectly affected by chemical and physical changes in the environment. Water quality conditions that significantly affect lower levels of the food chain will also affect the abundance, species composition, and condition of the fish community. While use of aquatic macroinvertebrates and water chemistry are integral components in the assessment of water quality and documentation of constituents causing impairment, the condition of the fishery is the most meaningful index of water quality to the general public. In recent years the MDC has placed greater emphasis on fish communities as indicators of stream quality. Consequently, the IBI is a suitable metric for establishing the baseline condition of Joachim Creek, and is proposed to be used as an assessment tool during the slag investigation.

The use of reference sites is essential to determining biotic health. Reference sites will be selected to represent the best attainable habitat, water quality and biological parameters (or reference conditions) of a sampling strata (i.e., region, ecoregion). The characteristics of reference sites will vary among sampling strata and stream order. Reference sites/conditions must be selected with care because they establish the basis for making comparisons and for detecting use impairment. The overall goal in the characterization of the reference condition is to describe the biota that are optimal for the region and type of waterbody of interest (MDC, 2001). To date, a characterization of Joachim Creek, its watershed and tributaries and the Herculaneum area (from a surface water resource perspective) has not been conducted. Prior to the sampling of fish, a thorough characterization of a potential reference area will be completed. Data gathering techniques, such as the Stream Habitat Assessment Procedure and the water quality/physical characterization procedure (Section 5.1.1) will be utilized to make reference reach and study reach comparisons.

To determine baseline conditions of Joachim Creek, one reference reach upstream of the Site will be selected. Also, a study reach will be selected adjacent to or downstream of the Site. The selection process will involve habitat suitability, habitat comparability, and best professional judgment. The reference reach must mimic the study reach regarding habitat as much as possible. Habitat, whether it contributes to improved biotic integrity or lessens the biotic potential of the reach, should not play a factor in IBI scores. To insure that both the reference reach and study reach are similar in terms of habitat, Qualitative Stream Habitat Assessment Procedures (SHAPs) will be implemented as described in Section 5.1.1 and in #99-0034-SOP-05 in Appendix A of this SAP. The IBI will not commence until both reaches have been deemed similar, regarding habitat, using SHAPs. Exact locations of biotic sampling for the IBI will be made in the field prior to sampling by fishery biologists. If a reference reach cannot be found that directly compares to the study reach or vice versa, then spot sampling of representative habitat may be the selected course of action. In this scenario, the same level of effort (manpower and manhours) will be applied to the reference reach and the study reach. This judgment will also be made in the field by an experienced fisheries biologist. Biological sampling will take place using backpack electrofishing techniques in areas that are wadeable. Also, to obtain quantitative data in reaches of Joachim Creek that are too deep to wade, a boat electrofishing techniques may be used in the field to collect fish. Guidance from the MDNR/MDC will be solicited to maintain consistency, and if feasible, an MDNR/MDC biologist will accompany the field sampling crew. For the complete sampling methodology for the IBI, refer to #99-0034-SOP-04 in Appendix A of this SAP.

### **5.1.1 Habitat Evaluation and Water Quality/Physical Characterization Assessments**

To insure that the reference reach is comparable to the study reach with regard to habitat similarity, SHAPs will be conducted in the field prior to biological sampling. SHAPs are a qualitative approach to evaluate lotic habitat quality using features considered important to biotic integrity. SHAPs facilitate an assessment of stream quality predicted on 15 metrics

associated with bottom substrate type, channel morphology, hydrology, and riparian features. Each metric is subjectively assessed and assigned to one of four habitat quality categories. The total possible score for each metric can range from a high of 20 for bottom substrate, to eight for channel sinuosity and top-of-bank land use. The total score of the stream reach assessed forms the basis of the overall habitat quality rating for the stream and can be used as a tool for biocriteria assessments when evaluating the relationship of habitat quality to biotic integrity (IEPA, 1994). For a detailed explanation of SHAPs and associated field data sheets, refer to #99-0034-SOP-05 in Appendix A of this SAP.

Each reach will be scored using SHAPs outlined in IEPA, 1994. The score of the reference reach will be compared to the score of the study reach. The following table (Table 5-1) summarizes the similarity categories for site comparability assessments:

**Table 5-1. Stream Habitat Percent Similarity Categories for Site Comparability Assessments.**

HABITAT QUALITY CATEGORY	PERCENT SIMILARITY
Excellent (Very Similar to Reference)	$\geq 90\%$
Good (Slightly Different)	75-89%
Fair (Moderately Different)	60-74%
Poor (Substantially Different)	$\leq 59\%$

The reference reach and the study reach must have a percent similarity of 75% or greater to be utilized during the IBI. If this threshold is not reached with the reaches selected, then another reach will be chosen and SHAPs will be re-applied.

In addition to SHAPs, water quality data, physical characterization activities and habitat quality information will be collected in the area of the sampling reaches.

The presence of an altered habitat structure is considered one of the major stressors of aquatic systems. The presence of a degraded habitat can sometimes obscure investigations on the effects of toxicity and/or pollution. The assessments performed by many water resource agencies include a general description of the site, a physical characterization and water quality assessment, and a visual assessment of instream and riparian habitat quality. Together these data provide an integrated picture of several of the factors influencing the biological condition of a stream system (Barbour et. al., 1999).

The combination of physical characterization and water quality will provide insight as to the ability of the stream to support a healthy aquatic community, and to the presence of chemical and non-chemical stressors to the stream ecosystem (Barbour et. al., 1999). The following table (Table 5-2) describes what information is obtained during physical characterization/water quality collection activities.

**Table 5-2. Components to Physical Characterization/Water Quality Collection Activities Associated with Biological Sampling Reaches.**

PARAMETER	DESCRIPTION OF PARAMETER
Header Information	Stream name and location, Investigators, Date, Time, etc.
Weather Conditions	Current, past 24 hours, air temperature
Site Location/Map	Drawing of sampling reach and specific sample locations

Stream Characterization	Subsystem, origin, type, catchment area
Watershed Features	Predominant Surrounding Landuse, local watershed NPS pollution, local watershed erosion
Riparian Vegetation	Dominant type and dominant species present
Large Woody Debris (LWD)	LWD in m <sup>2</sup> , Density of LWD m <sup>2</sup> /km <sup>2</sup>
Aquatic Vegetation	Dominant type and dominant species present
Water Quality	Temperature, specific conductance, dissolved oxygen, pH, turbidity, instruments used, water odors, presence of surface oils
Sediment/Substrate	Odors, oils, deposits
Inorganic Substrate Components	Substrate type and percent composition in the sampling reach
Organic Substrate Components	Substrate type and percent composition in the sampling reach

The habitat quality evaluation can be accomplished by characterizing selected physicochemical parameters in conjunction with a systematic assessment of physical structure. Through this approach, key features can be rated or scored to provide a useful assessment of habitat quality (Barbour et. al., 1999). The following table (Table 5-3) describes what information is obtained during habitat assessment activities.

**Table 5-3. Components to Habitat Assessment Activities Associated with Biological Sampling Reaches.**

HABITAT PARAMETER	DESCRIPTION
Epifaunal Substrate/Available Cover	Includes the relative quantity and variety of natural structures in the stream, such as cobble (riffles), large rocks, fallen trees, logs and branches, and undercut banks, available as refugia, feeding, or sites for spawning and nursery functions of aquatic macrofauna.
Pool Substrate Characterization	Evaluates the type and condition of bottom substrates found in pools.
Pool Variability	Rates the overall mixture of pool types found in streams, according to size and depth.
Sediment Deposition	Measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition.
Channel Flow Status	The degree to which the channel is filled with water.
Channel Alteration	Measure of large-scale changes in the shape of the stream channel.
Channel Sinuosity	Evaluates the meandering or sinuosity of the stream.
Bank Stability	Measures whether the stream banks are eroded (or have the potential

	for erosion).
Vegetative Protection	Measures the amount of vegetative protection afforded to the stream bank and the near-stream portion of the riparian zone.
Riparian Vegetation Zone Width	Measures the width of natural vegetation from the edge of the stream bank out through the riparian zone.

Complete protocols for the Physical Characterization/Water Quality evaluation and Habitat Assessment for biological sampling are found in #99-0034-SOP-06 in Appendix A of this SAP.

## 5.2 Quantitative Floristic Community Survey

To aid in determining baseline conditions of the Study Area as well as determine potential exposure of natural resources to COPCs, a quantitative floristic community survey will be performed. During a site visit by ELM in November of 2000, four habitat types were observed in the area of the Site. These included:

- Mature floodplain forest;
- Successional floodplain forest;
- Emergent wetland; and
- Scrub-shrub wetland

Mature floodplain forest was located west, south and southeast of the slag pile across Joachim Creek. Additionally, a narrow corridor of mature floodplain forest remained along the riparian corridor of Joachim Creek immediately south of the slag pile (Figure 8). Large stands of silver maple (*Acer saccharinum*), green ash (*Fraxinus pennsylvanica*) Eastern sycamore (*Platanus occidentalis*), American elm (*Ulmus americana*) and box elder (*Acer negundo*) were observed in these areas during the site visit. Historical aerial photographs, particularly the 1966 and 1978 photographs (Appendix D), show heavy cultivation of the slag pile storage area before it was utilized as a slag storage area by Doe Run. However, this strip of mature floodplain forest remained and currently has mature trees very similar to the non-cultivated floodplain forest across Joachim Creek to the south.

Areas of the floodplain that were cultivated in the 1950's and 1960's are currently in various stages of succession near the Site. The area between the slag pile and Joachim Creek, the "Future Waste Management Area" and areas across Joachim Creek east of the slag pile all show signs of succession (Figure 8). The canopy in these areas show the same tree species as that of the mature floodplain forest are but much less mature.

The two remaining habitat types have developed from the creation of the borrow pit southeast of the slag pile (Figure 8). The 1978 historical aerial photograph shows the borrow pit prior to being inundated with water (Appendix D). Adjacent to the slag pile is a large area of emergent wetland dominated by what appeared to be rice cutgrass (*Leersia oryzoides*). At the time of the site visit, the area was inundated to a depth of approximately six inches. To the southeast of the emergent wetland, a monotypic stand of willow (*Salix* sp.) was observed. This area was also inundated to a depth of six-ten inches.

In addition to historical aerial photographs, National Wetland Inventory (NWI) maps from the USFWS were reviewed and similar habitat designations were given to the areas under investigation (Appendix E).

The following table (Table 5-4) describes the NWI designations in the Study Area of the SI.

Table 5-4. Summary of NWI Designations for Habitats within the Study Area.

HABITAT	LOCATION	USFWS DESIGNATIONS	EXPLANATION OF DESIGNATIONS
Mature Floodplain Forest	West, south and southeast of the slag pile; across Joachim Creek	PFO1C	Palustrine Forested Broad-Leaved Deciduous Seasonally Flooded
Successional Floodplain Forest	Northwest and east of the slag pile; across Joachim Creek	PFO1C	Palustrine Forested Broad-Leaved Deciduous Seasonally Flooded
Emergent Wetland/Scrub-Shrub Wetland	In former borrow pit area; southeast of the slag pile	P <u>SS1</u> C EM	Palustrine Scrub-Shrub Broad-Leaved Deciduous Emergent Seasonally Flooded

As shown in Appendix E, the NWI map generally describes the current site conditions. Various site-specific conditions have changed due to historic and current land use. All current wetland habitat information will be added to Figure 4 once the quantitative floristic survey and wetland delineation are complete.

Because of the floristic community present in each of these habitat types, only the mature floodplain forest, the successional floodplain forest and the emergent wetland will be evaluated quantitatively. The scrub-shrub wetland (willow stand) will be qualitatively evaluated during the qualitative floristic community survey as described in Section 5.3. Because of the monotypic nature of the willow stand, a quantitative survey would yield little valuable information for such a level of effort. During the qualitative observations, a species list will be generated and the total acreage of the wetland will be estimated.

As shown on Figure 8, a total of 11 transects have been proposed to fully characterize each habitat type as well as obtain floristic measurements from reference locations. Two (2) transects have been established within the emergent wetland southeast of the slag pile. Quantitative data will be useful in this specific habitat to ascertain whether this area is in very early stages of succession. If saplings are present within this area and it is predicted that the emergent wetland will revert back to floodplain forest in the future, then this information will be very helpful during the development of potential restoration strategies during subsequent Phases of the SI. Three (3) transects have been proposed in successional floodplain forest between the slag pile and Joachim Creek. In conjunction with these three transects, two transects, which represent reference locations for successional floodplain forest, have been established east of the slag pile and across Joachim Creek (Figure 8). To evaluate mature floodplain forest, two (2) transects are proposed along the riparian corridor between the slag pile and Joachim Creek. In conjunction with these two transects, two transects, which represent reference locations for mature floodplain forest, have been established west of the slag pile, across Joachim Creek (Figure 8).

The use of reference transects will be crucial when comparing potentially impacted habitats with those that have not been influenced by the operation of the Site. The habitat information

obtained during the review of historical aerial photographs (Appendix D) and the site visit in November, 2000 has lead to the transect location decision strategy (both investigative and reference). Exact locations will be established in the field by trained botanist prior to the survey. The following table (Table 5-5) summarizes the number and locations of the quantitative floristic survey transects:

**Table 5-5. Number and Location of the Quantitative Floristic Survey Transects.**

HABITAT TYPE	TYPE OF TRANSECT	NUMBER OF TRANSECTS	LOCATION OF TRANSECT
Mature Floodplain Forest	Investigative	2	Along the riparian corridor, south of the slag pile
	Reference	2	West of slag pile; across Joachim Creek
Successional Floodplain Forest	Investigative	3	South of the slag pile between the slag pile and Joachim Creek
	Reference	2	West of the slag pile; across Joachim Creek
Emergent Wetland	Investigative	2	In the former borrow pit area; southeast of the slag pile
	Reference	-	-

### 5.2.1 Quantitative Survey Metrics

Depending upon which floral community is present, the following habitat types (Table 5-6) will be sampled and the following sampling indices will be utilized to assess the plant assemblage:

**Table 5-6. Habitat Types, Communities and Indices Associated with the Floristic Survey.**

HABITAT TYPE	VEGETATIVE COMMUNITY	INDEX
Successional Floodplain Forest	Canopy, Subcanopy, Shrub, Herb Cover	Density, Basal Area, Cover, Herb Species Richness
Mature Floodplain Forest	Canopy, Subcanopy, Shrub, Herb Cover	Density, Basal Area, Cover, Herb Species Richness
Emergent Marsh Wetland	Shrub, Herb Cover	Density, Cover, Herb Species Richness

The metrics to be used will yield information as to the dominant species present within each habitat type. Each of the metrics are summarized below.

The various metrics to be utilized in the field to obtain quantifiable data include:

- Frequency;
- Density;
- Basal Area; and
- Herb Species Richness

Frequency is the percentage of the sample units in which a species occurs. If, for example, 50 small plots were examined in a study site and bitterbrush occurred in 20 of those plots, the frequency of bitterbrush would be  $20/50 \times 100$ , or 40%. Frequency is a simple attribute to estimate because the plant either occurs in the sample unit or it does not. Frequency is a useful characteristic for describing the distribution of plants within a community, and it is useful for monitoring changes in the plant community over time or comparing different communities.

Density is the total number of objects (e.g., individual plants, seeds) per unit area. One advantage of the density parameter is that count data are straightforward to obtain and interpret, and results obtained from various methods are directly comparable.

Stand basal area is a very useful parameter for quantifying a forest stand. It may be seen as a summary of the number and the size of trees in a stand.

Herb species richness will be calculated as number of species per plot or quadrat. The Daubenmire Cover Scale will be used to determine what percentage each species of plant is covering the area of the 1 m<sup>2</sup> quadrat.

### **5.2.2 Quantitative Survey Sampling Approach**

The floristic survey will be performed with a random transect/plot/quadrat approach. The length of a main sampling transect will be determined by the size of the habitat being sampled. The maximum length of any main transect will be 100 meters. Four (4) "perpendicular transects" are randomly established perpendicular to the main transect. A 400 m<sup>2</sup> plot is then randomly positioned on the terminal ends of each of the perpendicular transects which yields a total of eight (8) 400 m<sup>2</sup> plots. Located within the center of each of the 400 m<sup>2</sup> plots are 40 m<sup>2</sup> subplots. Finally, five (5) 1 m<sup>2</sup> quadrats are randomly set within each quarter section of the 400 m<sup>2</sup> plot yielding 20-1 m<sup>2</sup> quadrats within each 400 m<sup>2</sup> plot. All perpendicular transects, 400 m<sup>2</sup> plots and 1 m<sup>2</sup> quadrats are randomly set within this survey model. A minimum of one (1) meter distance will be obtained between plots to avoid crossing plot boundaries. To attempt not to have any cross-community effects during sampling along the edges of two community types (i.e., a successional floodplain forest transitioning to an emergent wetland), the terminating points of each transect will remain five meters off of each ecotone. For a complete description of this quantitative floristic survey method, field data sheets and a diagram of the survey model, refer to #99-0034-SOP-07 in Appendix A of this SAP.

### **5.2.3 QC Procedures During the Quantitative Survey**

As described in SOP #99-0034-SOP-07, no sampling will occur across natural community borders. For example, sampling locations will not cross from a successional floodplain forest to a mature floodplain forest as the floristic assemblage will be different from one natural

community to another. Therefore, each sampling transect and plot will remain, at a minimum, five (5) meter off of the adjacent ecotone.

For this sampling methodology, two teams of two people will be conducting the survey. Each team will have an experienced botanist who will identify the plant species and conduct each metric described in Section 5.2.1. To insure that subjectivity is kept to a minimum during the calculation of herb species richness, the botanists will cross-check each other work by estimating the percentage of cover from the other team's quadrats at a frequency determined by the QA Manager. If differences in estimated cover, from one botanist to the other, are beyond QA/QC standards, the sampling crew will cease work and a review of the floristic survey methods will be conducted by Doe Run.

In the interest of cooperation, an agency (MDC/MDNR) botanist will be asked to accompany the field crew during the survey to provide input and observe sampling methodology.

### **5.3 Qualitative Threatened and Endangered Plant Species Survey**

As part of Phase I of the NRDA and the habitat map, a qualitative threatened and endangered plant species survey will be conducted within the Study Area. The results of the survey will aid in determining baseline conditions of the habitats surveyed as well as document sensitive areas that will be avoided if/when remedial activities occur.

According to a letter from the MDC staff (Appendix B), there are no federally listed or state listed threatened or endangered plant species found in the Missouri Natural Heritage Database with specific regard to the lower Joachim Creek area or Herculaneum, Missouri. However, according to the MDC, the Fremont's Leather Flower (*Clematis fremontii*), a "rare and uncommon plant in Missouri", has been identified approximately four miles west of the Site.

#### **5.3.1 Survey Activities**

To perform the survey, a trained botanist, whose expertise includes state-listed plant species of Missouri as well as indicator species information and habitat preference, will become familiar with the study area through the observation of aerial photographs. A biologist with ELM will provide all necessary site background, history and habitat information required by the botanist. Additionally, the botanist will tour all major habitat types and areas of concern in the Site and Study Area to observe site-specific characteristics. Once the botanist is comfortable with the introduction to the Study Area, the ELM biologist and the botanist will determine areas of suitable habitat for the various threatened and endangered species that could potentially be found in the Study Area. When these strategic areas are determined, the ELM biologist and the botanist will perform the survey.

The survey will consist of visual observation by the botanist of all flora of a particular suitable habitat. The botanist will look for threatened and endangered species and indicator species that may show the potential of a threatened or endangered plant occurring in that area. Additionally, the botanist will look for suitable habitat where a state-listed species may occur. General floristic community observations will be documented on the Qualitative Floristic Survey field data sheet (#99-0034-SOP-14). If a state-listed plant species is observed in the study area, the exact location will be documented and the area of the plant(s) will be flagged. The threatened and endangered plant discovery field data sheet (#99-0034-SOP-14) will be completed. The MDNR will immediately be notified as to the presence of the state-listed species. The area where the plant(s) was observed will then be more extensively demarcated so that no evasive activities occur at or near the location of the plant(s). For a complete

description of the qualitative floristic survey and field data sheets, refer to #99-0034-SOP-14 in Appendix A of this SAP.

#### **5.4 Wetland Delineation**

On November 11, 2000, ELM contacted the regulatory branch of the United States Army Corps of Engineering (ACOE) that has jurisdiction over the Herculaneum, MO area to inquire about relevant wetland delineation information within the Site and Study Area. On March 24, 1999, representatives from the ACOE established four data points along the Joachim Creek watershed for the purposes of delineating wetlands in the area (Appendix C of this SAP). Three data points were located between Joachim Creek and the slag pile to the west (1-1), southwest (1-2) and south (1-3). A fourth data point was located west of Joachim Creek upstream of the Site (2-1). All four data point locations showed hydrophytic vegetation and wetland hydrology characteristics. No hydric soil information was made available to ELM.

As part of the NRDA, a wetland delineation will be performed within the Study Area where jurisdictional wetlands are suspected. The results of the survey will aid in determining baseline conditions of the habitats surveyed as well as show sensitive areas that will be avoided if/when remedial activities occur.

During a site visit conducted by ELM personnel in November, 2000, three habitat types where wetlands were suspected were observed adjacent to or near the Study Area. These areas included: (1) successional floodplain forest located south, west and east of the Site; (2) emergent marsh located adjacent to the Site to the south; and (3) scrub-shrub wetland in the area of the former borrow pit (Figure 8). Because wetland characteristics such as hydrophytic vegetation and inundation were identified in the study area, wetland delineation activities are warranted.

To determine wetland environments within the Study Area, a wetland delineation will be performed. The wetland delineation will encompass two separate tasks:

- Field Reconnaissance; and
- Wetland Delineation Summary Report

During the field reconnaissance, an investigation of the Study Area will be completed to determine the limits of the wetlands present. The wetland delineation will be completed based on the methodology established by the ACOE. Also during the site visit, wildlife and plant community qualities will be assessed. The limits of the wetland community will be field staked so that they can be located in relation to study areas boundaries currently present on existing study area maps.

The results of the field reconnaissance will be summarized in a report, including an exhibit depicting the approximate Study Area wetland boundaries. The report will be suitable for submittal to the ACOE as part of a Section 404 permit application if/when a wetland habitat is to be altered in any way. The wetlands' generalized quality ratings will be included along with exhibits depicting the approximate wetland and project boundaries. National Wetland Inventory maps, Soil Survey, floodplain, USGS topographic maps, site photographs and the ACOE Routine On-Site Data Forms will be included.

To quantify the exact wetland acreage and to determine precise location, all wetland boundaries will be surveyed under a separate task.

## 6 Literature Cited

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**APPENDIX A**  
**FIELD STANDARD OPERATING PROCEDURES**  
**AND**  
**ASSOCIATED FIELD DATA SHEETS**



## **Standard Operating Procedure (#99-0034-SOP-01) for Collecting Surface Water Samples for the Purposes of Inorganic Analysis**

### **1. Scope & Summary**

This standard operating procedure (SOP) outlines techniques for collecting ambient water samples from shallow freshwater streams, ponds, inland lakes, drainage pathways and ephemeral water bodies for inorganic chemical analysis. This method is not designed for collecting ambient water samples for organic analysis. This method is described for deployment from a small, stable boat or on foot.

#### **1.1. Summary of Method**

1.1.1. The analytical laboratory provides clean sample containers.

1.1.2. The laboratory or cleaning facility will provide a carboy or other appropriate clean-container filled with reagent water for use with collection of field blanks during sampling activities. At least one field blank will be processed for each sampling event, or one per every ten samples, whichever is more frequent.

1.1.3. Sampling personnel will wear clean, nontalc gloves at all times when handling sample containers.

1.1.4. In addition to processing field blanks, it is recommended that a field duplicate be collected during each sampling event, or one field duplicate per every ten samples, whichever is more frequent.

#### **1.1.5. Sampling**

1.1.5.1. Whenever possible, samples are collected facing upstream and upwind to minimize introduction of contamination.

1.1.5.2. Samples may be collected while working from a boat or while wading in shallow water.

1.1.5.3. Surface samples are collected using a grab sampling technique. The principle of the grab technique is to fill a sample bottle by rapid immersion in water and capping to minimize exposure to airborne particulate matter.

### **2. Reference Documents**

2.1. USEPA (1982) *Handbook for sampling and sample preservation of water and wastewater*. EPA-600/4-82-029. U.S. Environmental Protection

Agency, Environmental Monitoring and Support Laboratory, Cincinnati OH  
402 pp.

- 2.2. U.S. Environmental Protection Agency, (USEPA, third edition). *SW-846 Test Methods for Evaluating Solid Wastes-Physical/Chemical Methods*. Office of Solid Waste.

### **3. Significance and Use**

The method is designed for investigation of inorganic inputs into shallow freshwater streams, ponds, inland lakes, drainage pathways and ephemeral water bodies from their watersheds.

### **4. Potential Interferences**

There are numerous routes by which samples may become contaminated. Potential sources of inorganic contamination during sampling include metallic or metal-containing sampling equipment, containers, labware (e.g. talc gloves that contain high levels of zinc), reagents, and deionized water, improperly cleaned and stored equipment, labware, and reagents; and atmospheric inputs such as dirt and dust from automobile exhaust, cigarette smoke, nearby roads, bridges, wires, and poles.

- 4.1. Avoiding contamination - The best way to control contamination is to completely avoid exposure of the sample to contamination in the first place. Avoiding exposure means performing operations in an area known to be free from contamination. Two of the most important factors in avoiding/reducing sample contamination are (1) an awareness of potential sources of contamination and (2) strict attention to work being performed. For example, water samples will be collected before measuring flow or collecting water chemistry data with field probes.
- 4.2. Minimize exposure - The Apparatus (including sample bottles, bags and coolers) that will contact samples or blanks should only be opened while in the process of sample collection so that exposure to atmospheric inputs is minimized. When not being used, the Apparatus should be stored in a cooler to avoid cross-contamination.
- 4.3. Wear gloves - Sampling personnel must wear clean, nontalc gloves during all operations involving handling of the Apparatus, samples, and blanks. Only clean gloves may touch the Apparatus. If another object of substance is touched, the glove(s) must be changed before again handling the Apparatus. If it is even suspected that gloves have become contaminated, work must be halted, the contaminated gloves removed, and a new pair of clean gloves put on. Wearing multiple layers of clean gloves will allow the old pair to be quickly stripped with minimal disruption to the work activity.
- 4.4. Use metal-free Apparatus - All Apparatus should be nonmetallic and free of material that may contain metals. When it is not possible to obtain equipment that is completely free of the metal(s) of interest, the sample should not come into direct contact with the equipment.

- 4.4.1. The Apparatus should be clean when the sampling team receives it. If there are any indications that the Apparatus is not clean (e.g., a ripped storage bag), an assessment of the likelihood of contamination must be made. Sampling must not proceed if it is possible that the Apparatus is contaminated. If the Apparatus is contaminated, it must be returned to the laboratory or cleaning facility for proper cleaning before any sampling activity resumes.
- 4.5. Avoid sources of contamination – Avoid contamination by being aware of potential sources and routes of contamination.
  - 4.5.1. Contamination by carryover – Contamination may occur when a sample containing low concentrations of inorganics is processed immediately after a sample containing relatively high concentrations. At sites where more than one sample will be collected, the sample known or expected to contain the lowest concentration of inorganics should be collected first with the sample containing the highest levels collected last (Section 10.1.3). This will help minimize carryover of inorganics from high-concentration samples to low-concentration samples. To avoid carryover from ancillary instruments (i.e., dissolved oxygen, pH or conductivity probes), collection of ancillary measurements will occur after collection of samples for inorganic analysis.
  - 4.5.2. Contamination by airborne particulate matter – Less obvious substances capable of contaminating samples include airborne particles. Samples may be contaminated by airborne dust, dirt, particulate matter, or vapors from automobile exhaust; cigarette smoke; nearby corroded or rusted bridges, pipes, poles, or wires; nearby roads. Whenever possible, the sampling activity should occur as far as possible from sources of airborne contamination (Section 10.1.2). Areas where nearby soil is bare and subject to wind erosion should be avoided.
  - 4.5.3. Boat
    - 4.5.3.1. Immediately before use, the boat should be washed with water from the sampling site away from any sampling points to remove any dust or dirt accumulation. Before first use, the boat should be cleaned and stored in an area that minimizes exposure to dust and atmospheric particles. For example, cleaned boats should not be stored in an area that would allow exposure to automobile exhaust or industrial pollution.

- 4.5.3.2. The boat should be frequently visually inspected for possible contamination.
  - 4.5.3.3. After sampling, the boat should be returned to the laboratory cleaning facility, cleaned as necessary, and stored away from any sources of contamination until next use.
  - 4.5.3.4. Samples should be collected upstream of boat movement.
- 4.6. Interferences – Interferences resulting from samples will vary considerably from source to source, depending on the diversity of the site being sampled. If a sample is suspected of containing substances that may interfere in the determination of inorganics, sufficient sample should be collected to allow the laboratory to identify and overcome interference problems.

## **5. Materials**

- 5.1. Sample bottles – Plastic (polyethylene) with lids.
- 5.2. Gloves – clean, nontalc, PVC; various lengths. Shoulder-length gloves are needed if samples are to be collected by direct submersion of the sample bottle into the water.
  - 5.2.1. Gloves, PVC – Fisher Scientific Part No. 11-394-100B, or equivalent.
- 5.3. Storage bags – clean, zip-type, nonvented, colorless polyethylene (various sizes).
- 5.4. Plastic wrap – clean, colorless polyethylene.
- 5.5. Cooler – clean, nonmetallic, with white interior for shipping samples.
- 5.6. Ice or chemical refrigerant packs – to keep samples chilled in the cooler during shipment.
- 5.7. Dissolved oxygen meter and probe.
- 5.8. pH meter and probe.
- 5.9. Specific conductance meter and probe.
- 5.10. Temperature probe.
- 5.11. Waterproof marking pens.

- 5.12. Sample data forms/clip board.
- 5.13. Hach kit.
- 5.14. Camera and film.
- 5.15. Personal and safety gear.
- 5.16. Field notebook.
- 5.17. Boat - A metal-free (e.g., fiberglass) boat, along with wooden or fiberglass oars or paddles. Gasoline- or diesel-fueled boat motors should be avoided when possible because the exhaust can be a source of contamination. If the body of water is large enough to require use of a boat motor, the engine should be shut off at a distance far enough from the sampling point to avoid contamination, and the sampling team should manually propel the boat to the sampling point. Samples should be collected upstream of boat movement.

## **6. Hazards and Precautions**

- 6.1. Operating in and around waterbodies carries the inherent risk of drowning. Life jackets must be worn when operating from a boat, when sampling in more than a few feet of water, or when sampling in swift currents.
- 6.2. *Collecting samples in cold weather, especially around cold water bodies, carries the risk of hypothermia, and collecting samples in extremely hot and humid weather carries the risk of dehydration and heat stroke. Sampling team members should wear adequate clothing for protection in cold weather and should carry an adequate supply of water or other liquids for protection against dehydration in hot weather.*
- 6.3. A project Health and Safety Plan will be written to address all potential and inherent health and safety issues surrounding the sampling of surface water.

## **7. Sample Preparation**

- 7.1. Sample locations may be adjusted on-site as deemed necessary by physical obstructions, or other factors. A pre-sampling site inspection should be conducted to evaluate for sampling limitations of desired locations.
- 7.2. Appropriate sample containers will be obtained from the analytical laboratory.
- 7.3. The Field Team Leader will read the Quality Assurance Project Plan before field sampling procedures are undertaken to understand how many, and what type of QA/QC samples are required.

- 7.4. The Field Team Leader must read the Health and Safety Plan prior to sampling to review applicable safety requirements.

## **8. Preparation of Apparatus**

- 8.1. The field meters and probes should be calibrated and tested.
- 8.2. Inspect boat to verify that all associated parts and equipment are in working order.

## **9. Calibration & Standardization**

- 9.1. The field meters (i.e., pH, dissolved oxygen, and specific conductance) will be calibrated according to the manufacturer's manuals.

## **10. Sample Collection and Handling Procedure**

- 10.1. Site selection - Identify the sample location from the sampling map.

- 10.1.1. Ideally, the selected sampling location will exhibit a high degree of cross-sectional homogeneity. It may be possible to use previously collected data to identify locations for samples that are well mixed or are vertically or horizontally stratified. Since mixing is principally governed by turbulence and water velocity, the selection of a site immediately downstream of a riffle area will ensure good vertical mixing. Horizontal mixing occurs in constrictions in the channel. In the absence of turbulent areas, the selection of a site that is clear of immediate point sources, such as industrial effluents, is preferred for the collection of ambient water samples.

- 10.1.2. To minimize contamination from inorganics in the atmosphere, ambient water samples should be collected from sites that are as far as possible (e.g., at least several hundred feet) from any metal supports, bridges, wires or poles. Similarly, samples should be collected as far as possible from regularly or heavily traveled roads. If it is not possible to avoid collection near roadways, it is advisable to study traffic patterns and plan sampling events during lowest traffic flow.

- 10.1.3. The sampling activity should be planned to collect samples known or suspected to contain the lowest concentrations of inorganics first, finishing with the samples known or suspected to contain the highest concentrations.

- 10.2. Sample collection procedure - Samples will be collected directly in the sample container. This procedure is the simplest and provides the least potential for contamination because it requires the least amount of equipment and handling.

- 10.2.1. The sampling team should ideally approach the site from down current and downwind to prevent contamination of the sample by particles sloughing off the boat, waders or equipment. If it is not possible to approach from both, the site should be approached from down current if sampling from a boat or approached from downwind if sampling on foot. When sampling from a boat, the bow of the boat should be oriented into the current (the boat will be pointed upstream). All sampling activity should occur from the bow.

*If the samples are being collected from a boat, it is recommended that the sampling team create a stable workstation by arranging the cooler or shipping container as a work table on the upwind side of the boat, covering this worktable and the upwind gunwale with plastic wrap or a plastic tablecloth, and draping the wrap or cloth over the gunnel. If necessary, duct tape is used to hold the wrap or cloth in place.*

- 10.2.2. Extreme care must be taken during all sampling operations to minimize exposure of the sample to human, atmospheric, and other sources of contamination. Whenever possible, the sample bottle should be opened, filled, and closed while submerged.
- 10.2.3. Manual collection of surface water samples will occur directly into the sample bottle.
- 10.2.3.1. At the site, all sampling personnel must don PVC sampling gloves (Section 5.2).
- 10.2.3.2. One sampler fills out the sample label while the other sampler retrieves the sample bottle.

- 10.2.3.3. Sampler submerges the sample bottle, unscrews the lid and allows the bottle to partially fill with sample. Sampler screws the lid on the bottle, shakes the bottle several times, and empties the rinsate away from the site. After two more rinsings, the sampler holds the bottle under water and allows bottle to fill with sample. After the bottle has filled (i.e., when no more bubbles appear), and while the bottle is still inverted so that the mouth of the bottle is underwater, the sampler replaces the cap of the bottle. In this way, the sample has never contacted the air. The sampler should not disturb the sediments while submerging the sample bottle. The goal of the sampling regime is to perform analysis on the ambient water collected and not on artifacts from the sediment.
- 10.2.3.4. Once the bottle lid has been replaced, the sampler attaches the sample label to the sample bottle and places the sample in a cooler with ice.
- 10.2.3.5. Documentation - after each sample is collected, the sample number is documented in the sampling log, and any unusual observations concerning the sample and the sampling are documented.
- 10.2.3.6. Sample collectors will remove and dispose of gloves and then collect water quality information.

## **11. Applicable Forms**

Surface Water Sampling Field Data Sheet

Field Audit for Surface Water Sampling

Audit Finding Record

Photograph Log

**ELM** CONSULTING, L.L.C.  
 600 Hart Road, Suite 130  
 Barrington, Illinois 60010

## Surface Water Sampling Field Data Sheet

Project Description		Field Team Leader	
Project No.	Date	Time	
Sampling Personnel			
Sample ID			
Description of Sample Location & Observations			
Sunny <input type="checkbox"/>	Partly Sunny <input type="checkbox"/>	Cloudy <input type="checkbox"/>	Raining <input type="checkbox"/>
Calm <input type="checkbox"/>	Slightly Windy <input type="checkbox"/>	Windy <input type="checkbox"/>	Gusting Winds <input type="checkbox"/>
Ambient Air Temperature (°F):		Flow:	
Specific conductance (µmhos)		Water temperature (°C)	
pH		Dissolved oxygen (mg/L)	
Water samples collected (check)		Redox:	
<input type="checkbox"/>	Priority pollutant metals	<input type="checkbox"/>	Individual Metal _____
<input type="checkbox"/>	Skinner List of Inorganics	<input type="checkbox"/>	Individual Metal _____
<input type="checkbox"/>	Total Organic Carbon	<input type="checkbox"/>	Individual Metal _____
<input type="checkbox"/>	Individual Metal _____	<input type="checkbox"/>	Other _____
<input type="checkbox"/>	Individual Metal _____	<input type="checkbox"/>	Other _____
Comments			

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 600 Hart Road, Suite 130  
 Barrington, Illinois 60010

## Audit Checklist for Surface Water Sampling

Project Description	Field Team Leader
Project No.	Audit Date
Sampling personnel	Audit No.

Audit Question	S	U	N/A	comments
Were all personnel briefed on their assignment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Did the crew have all the forms and maps, equipment and materials necessary to complete the assigned tasks?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were the sampling locations correctly identified on the forms?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were the field meters properly calibrated?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were samples collected according to the procedure and all potential interferences addressed before sampling?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Was the depth of the sediment samples consistent?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were sample locations properly marked for the survey crew?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were the sampling equipment and meter probes properly cleaned between sample locations?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were all sample containers properly labeled?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were all sample containers properly filled (e.g. no head space)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were all samples properly packed for shipping?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
packed in ice?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
custody seals in appropriate places?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Did personnel adhere to the safety procedures?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Auditor Signature: \_\_\_\_\_

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 600 Hart Road, Suite 130  
 Barrington, Illinois 60010

## Audit Finding Report

Project No.	Task No.	Audit No.	Audit Date
Individual(s) contacted		Auditor Signature	
Requirements			
Findings			
Recommended Corrective Action			
Scheduled Response Date		Responsible for Corrective Action	
Corrective Action Taken			
Date	Submitted by	Management Approval	
Date Response Received		Response Acceptable?    Yes    No	
Reason for Rejection			
Verification			
Date Verified		Auditor Signature	

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 Barrington, Illinois 60010

## Photograph Log

Project Description		Field Team Leader	
Project No.	Task No.	Photos By	
Date(s)		Location	
Film Type		Roll/Disk #	of
Frame	Subject/Sample ID	Frame	Subject/Sample ID
1		19	
2		20	
3		21	
4		22	
5		23	
6		24	
7		25	
8		26	
9		27	
10		28	
11		29	
12		30	
13		31	
14		32	
15		33	
16		34	
17		35	
18		36	



## **Standard Operating Procedure (#99-0034-SOP-02) for Collecting Sediment Samples for the Purposes of Inorganic Analysis**

### **1. Scope & Summary**

This standard operating procedure (SOP) outlines techniques for collecting sediment samples from shallow freshwater streams, ponds, inland lakes, drainage pathways and ephemeral water bodies for inorganic chemical analysis. This method is not designed for collecting sediment samples for organic analysis. This method is described for deployment from a small, stable boat or on foot.

Sediment samples are collected using a core sampler, and samples are placed into clean, labeled jars with minimum headspace and packed in ice (in coolers) during transportation to the laboratory. If no water is present in sampling locations that are only temporarily inundated, then a non-metallic trowel will be used to collect the sediment sample.

#### **1.1. Summary of Method**

1.1.1. The analytical laboratory provides clean sample containers.

1.1.2. The laboratory or cleaning facility will provide a carboy or other appropriate clean-container filled with reagent water for use with collection of field blanks during sampling activities. At least one field blank will be processed for each sampling event, or one per every ten samples, whichever is more frequent.

1.1.3. Sampling personnel will wear clean, nontalc gloves at all times when handling sample containers.

1.1.4. In addition to processing field blanks, it is recommended that a field duplicate be collected during each sampling event, or one field duplicate per every ten samples, whichever is more frequent.

#### **1.1.5. Sampling**

1.1.5.1. Whenever possible, samples are collected facing upstream and upwind to minimize introduction of contamination.

1.1.5.2. Samples may be collected while working from a boat or while wading in shallow water.

### **2. Reference Documents**

- 2.1. ASTM (E1391-90) *Standard guide for collection, storage, characterization and manipulation of sediments for toxicological testing*. American Society for Testing and Materials, Annual Book of ASTM Standards. vol. 11.02, Philadelphia, PA.

- 2.2. Baudo, R (1990) *Sediment sampling, mapping and data analysis*. In *Sediments: the Chemistry and Toxicology of In-place Pollutants*. R Baudo, J Giesy & H Muntau (eds.). Lewis Publishers. Chelsea, MI pp. 15-60.
- 2.3. Mudroch, A & S MacKnight (1994) *Bottom sediment sampling*. In *Handbook of Techniques for Aquatic Sediments Sampling*. Second Edition. A Mudroch & S. MacKnight (eds.) Lewis Publishers, Ann Arbor, MI pp. 29-96.
- 2.4. USEPA (1985) *Sediment sampling quality assurance user's guide*. EPA 600/4/85/048. U. S. Environmental Protection Agency, Environmental Monitoring and Support Lab., Las Vegas, NV 114 pp.

### 3. Significance and use

The method is designed for investigation of inorganic inputs into shallow freshwater streams, ponds, inland lakes, drainage pathways and ephemeral water bodies from their watersheds. The samples collected by this method are suitable for chemical characterization, but may be inadequate for biological analyses such as benthos characterization.

### 4. Potential Interferences

There are numerous routes by which samples may become contaminated. Potential sources of inorganic contamination during sampling include metallic or metal-containing sampling equipment, containers, labware (e.g. talc gloves that contain high levels of zinc), reagents, and deionized water, improperly cleaned and stored equipment, labware, and reagents; and atmospheric inputs such as dirt and dust from automobile exhaust, cigarette smoke, nearby roads, bridges, wires, and poles.

- 4.1. Avoiding contamination - The best way to control contamination is to completely avoid exposure of the sample to contamination in the first place. Avoiding exposure means performing operations in an area known to be free from contamination. Two of the most important factors in avoiding/reducing sample contamination are (1) an awareness of potential sources of contamination and (2) strict attention to work being performed. For example, sediment samples will be collected before measuring flow or collecting water chemistry data with field probes.
- 4.2. Minimize exposure - The Apparatus (including sample bottles, bags and coolers) that will contact samples or blanks should only be opened while in the process of sampling so that exposure to atmospheric inputs is minimized. When not being used, the Apparatus should be stored in a cooler to avoid cross-contamination.
- 4.3. Wear gloves - Sampling personnel must wear clean, nontalc gloves during all operations involving handling of the Apparatus, samples, and blanks. Only clean gloves may touch the Apparatus. If another object of substance is touched, the glove(s) must be changed before again handling the Apparatus. If it is even suspected that gloves have become contaminated, work must be halted, the contaminated gloves removed, and a new pair of clean gloves put on. Wearing multiple layers of clean gloves will allow the old pair to be quickly stripped with minimal disruption to the work activity.
- 4.4. Use metal-free Apparatus - All Apparatus should be nonmetallic and free of material that may contain metals. When it is not possible to obtain

equipment that is completely free of the metal(s) of interest, the sample should not come into direct contact with the equipment.

- 4.4.1. The Apparatus should be clean when the sampling team receives it. If there are any indications that the Apparatus is not clean (e.g., an opened sample bottle), an assessment of the likelihood of contamination must be made. Sampling must not proceed if it is possible that the Apparatus is contaminated. If the Apparatus is contaminated, it must be returned to the laboratory or cleaning facility for proper cleaning before any sampling activity resumes.
- 4.5. Avoid sources of contamination – Avoid contamination by being aware of potential sources and routes of contamination.
  - 4.5.1. Contamination by carryover – Contamination may occur when a sample containing low concentrations of inorganics is processed immediately after a sample containing relatively high concentrations. At sites where more than one sample will be collected, the sample known or expected to contain the lowest concentration of inorganics should be collected first with the sample containing the highest levels collected last. This will help minimize carryover of inorganics from high-concentration samples to low-concentration samples. To avoid carryover from ancillary instruments (i.e., dissolved oxygen, pH or conductivity probes), collection of ancillary measurements will occur after collection of samples for inorganic analysis.
  - 4.5.2. Contamination by indirect contact – Apparatus that may not directly contact samples may still be a source of contamination. Therefore, it is imperative that every piece of the Apparatus that is directly or indirectly used in the collection of ambient water samples be cleaned by the laboratory prior to delivery to the site.
  - 4.5.3. Contamination by airborne particulate matter – Less obvious substances capable of contaminating samples include airborne particles. Samples may be contaminated by airborne dust, dirt, particulate matter, or vapors from automobile exhaust; cigarette smoke; nearby corroded or rusted bridges, pipes, poles, or wires; nearby roads. Whenever possible, the sampling activity should occur as far as possible from sources of airborne contamination. Areas where nearby soil is bare and subject to wind erosion should be avoided.
  - 4.5.4. Boat
    - 4.5.4.1. Immediately before use, the boat should be washed with water from the sampling site away from any sampling points to remove any dust or dirt accumulation. Before first use, the boat should be cleaned and stored in an area that minimizes exposure to dust and atmospheric particles. For example, cleaned boats should not be stored in an area that

would allow exposure to automobile exhaust or industrial pollution.

4.5.4.2. The boat should be frequently visually inspected for possible contamination.

4.5.4.3. After sampling, the boat should be returned to the laboratory cleaning facility, cleaned as necessary, and stored away from any sources of contamination until next use.

4.5.4.4. Samples should be collected upstream of boat movement.

- 4.6. Interferences - Interferences resulting from samples will vary considerably from source to source, depending on the diversity of the site being sampled. If a sample is suspected of containing substances that may interfere in the determination of inorganics, sufficient sample should be collected to allow the laboratory to identify and overcome interference problems.
- 4.7. The presence of headspace (bubbles) in sample containers might cause errors in the analytical chemistry data. Extra care must be taken to completely fill sample containers.
- 4.8. Residual sediment might remain in the core sampler and contaminate subsequent samples. To prevent contamination, all sampling gear must be thoroughly decontaminated between sample locations. Ideally, a new core sampler will be used for each individual sample.
- 4.9. Large objects (e.g. stones, sticks etc.) might obstruct the core barrel and prevent successful sample collection. If possible, sample locations should be selected to avoid these objects.
- 4.10. It might be difficult to penetrate very firm sediments (e.g. clay, gravel, or sand) with the core sampler. A pre-sampling site inspection should be conducted to evaluate the suitability of the sample gear for collecting samples.

## 5. Apparatus

The apparatus consists of a cylindrical (core barrel) core liner (cellulose acetate butyrate) that stabilizes the sediment sample, and a plastic spatula to retrieve the sample. The plastic core extruder consists of a long rod with a round platform at one end that has a diameter small enough to slide into the core barrel to extract the sediment. A plastic spatula or knife is used to transfer the sediment from the core barrel to the sample jar. This apparatus can be used in shallow (< 2 feet) waters.

## 6. Materials

- 6.1. Sample bottles - Plastic (polyethylene) with lids.
- 6.2. Gloves - clean, nontalc, PVC; various lengths. Shoulder-length gloves are needed if samples are to be collected by direct submersion of the sample bottle into the water.

- 6.2.1. Gloves, PVC – Fisher Scientific Part No. 11-394-100B, or equivalent.
- 6.3. Storage bags – clean, zip-type, nonvented, colorless polyethylene (various sizes).
- 6.4. Cooler – clean, nonmetallic, with white interior for shipping samples.
- 6.5. Ice or chemical refrigerant packs – to keep samples chilled in the cooler during shipment.
- 6.6. Core liners (cellulose acetate butyrate).
- 6.7. Core extruder.
- 6.8. Plastic spatula/knife.
- 6.9. Dissolved oxygen meter and probe.
- 6.10. pH meter and probe.
- 6.11. Specific conductance meter and probe.
- 6.12. Temperature probe.
- 6.13. Waterproof marking pens.
- 6.14. Sample data forms/clip board.
- 6.15. Hach kit.
- 6.16. Plastic wrap.
- 6.17. Duct tape.
- 6.18. Camera and film.
- 6.19. Personal and safety gear.
- 6.20. Field notebook.
- 6.21. Decontamination supplies (i.e., Formula 409).
- 6.22. Boat - For the purposes of this SOP, and for situations in which the presence of contaminants cannot otherwise be controlled below detectable levels, the following equipment and precautions may be necessary: A metal-free (e.g., fiberglass) boat, along with wooden or fiberglass oars or paddles. Gasoline- or diesel-fueled boat motors should be avoided when possible because the exhaust can be a source of contamination. If the body of water is large enough to require use of a boat motor, the engine should be shut off at a distance far enough from the sampling point to avoid contamination, and the sampling team should manually propel the boat to the sampling point. Samples should be collected upstream of boat movement.

## 7. Hazards & Precautions

- 7.1. Field-collected sediments might contain potentially toxic materials, and thus should be treated with caution to minimize exposure to workers. Waterproof clothing (waders) and gloves are recommended.

- 7.2. The project Health and Safety Plan must be reviewed to identify further hazards, precautions and safety procedures.
- 7.3. Operating in and around waterbodies carries the inherent risk of drowning. Life jackets must be worn when operating from a boat, when sampling in more than a few feet of water, or when sampling in swift currents.
- 7.4. Collecting samples in cold weather, especially around cold water bodies, carries the risk of hypothermia, and collecting samples in extremely hot and humid weather carries the risk of dehydration and heat stroke. Sampling team members should wear adequate clothing for protection in cold weather and should carry an adequate supply of water or other liquids for protection against dehydration in hot weather.

## **8. Sample Preparation**

- 8.1. Sample locations may be adjusted on-site as deemed necessary by the location of sedimentation zones, physical obstructions, or other factors. A pre-sampling site inspection should be conducted to evaluate whether these procedures are feasible for sampling the desired locations.
- 8.2. Appropriate new sample containers must be obtained from the analytical laboratory or a commercial supplier. The analytical procedures must be reviewed to identify the proper sample container material, size, and preparation.
- 8.3. The Field Team Leader must read the Quality Assurance Project Plan before field sampling procedures are undertaken to understand how many and what type of QA/QC samples are required.
- 8.4. The Field Team Leader must read the Health and Safety Plan prior to sampling to review applicable safety requirements.

## **9. Preparation of Apparatus**

- 9.1. All sampling equipment (core barrels, plastic spatulas, etc.) must be cleaned with a laboratory-grade detergent (Alconox ® or equivalent such as Formula 409®) and triple-rinsed with distilled water.
- 9.2. The field meters and probes should be calibrated and tested.

## **10. Calibration & Standardization**

- 10.1. The field meters (pH, dissolved oxygen, and specific conductance) must be calibrated according to the manufacturer's manuals.
- 10.2. The sediment extruder should be calibrated to facilitate the removal of a pre-selected volume of sediment from the core liner. A pre-sampling field inspection should be conducted to determine the practical minimum depth the corer will penetrate into the sediments at the site. All sediment samples should then be collected to this (minimum) depth so the analytical results will be comparable.
- 10.3. The extruder post should be calibrated (marked) so that the amount of sediment extruded can be selected. This procedure ensures that the same

amount of sediment is extruded from each core so that samples are consistent and comparable. A small snap-type clamp can be used to mark the point of maximum extrusion so that the field personnel can focus their attention on capturing the surficial sediment layer as it is extruded. In most sediments this layer will be very flocculent and can easily be lost.

## **11. Procedure**

To perform all of the operations necessary to collect a sediment sample properly using these methods, a total of three people will be needed.

- 11.1. Identify the sample location from the sampling map.
- 11.2. Retrieve all coring materials, and make the necessary preparations to collect samples from the marked sample stations. When sampling from a boat or barge, preparations to secure the boat with anchors must be made.
- 11.3. The sampling team should ideally approach the site from down current and downwind to prevent contamination of the sample by particles sloughing off the boat, waders or equipment. If it is not possible to approach from both, the site should be approached from down current if sampling from a boat or approached from downwind if sampling on foot. When sampling from a boat, the bow of the boat should be oriented into the current (the boat will be pointed upstream). All sampling activity should occur from the bow. If the samples are being collected from a boat, it is recommended that the sampling team create a stable workstation by arranging the cooler or shipping container as a work table on the upwind side of the boat, covering this worktable and the upwind gunwale with plastic wrap or a plastic tablecloth, and draping the wrap or cloth over the gunnel. If necessary, duct tape is used to hold the wrap or cloth in place.
- 11.4. To minimize unnecessary confusion, it is advisable that a third team member be available to complete the necessary sample documentation (e.g., to document sampling location, time, sample number, etc.).
- 11.5. Extreme care must be taken during all sampling operations to minimize exposure of the sample to human, atmospheric, and other sources of contamination.
- 11.6. At the site, sampling personnel must don nontalc, PVC gloves.
- 11.7. Collect sediment sample with the core barrel. The sampler presses the core barrel into the sediment with a constant pressure. If the sediment is firm, the sampler may be twisted in a clockwise manner to increase penetration. Before lifting the core barrel from the sediment, the sampler should place his/her gloved hand on top of the barrel to create a negative pressure environment within the core barrel. This will allow the sediments to remain in the barrel while retrieving the barrel.
- 11.8. The sampler retrieves the core sampler (lift vertically) when the core barrel has been inserted its full length into the sediment. When the core barrel has been removed from the sediment, the sampler should place his gloved-hand under the bottom of the barrel to support the sample in the core barrel. The sample may be firm enough to stay within the barrel, but the slightest movement of the barrel can dislodge the sample. While holding the bottom of the sample, the sampler should move into position of

retrieve the sample from the barrel. During this process, the second sampler can stabilize the core barrel while the other sampler positions other equipment to retrieve the sample.

- 11.9. Remove the sediment sample from the core barrel. The sampler holds the apparatus vertically while the other sampler places the core extruder beneath the core barrel to prevent the sediment sample from escaping.
- 11.10. The sampler opens the cooler or storage container and removes the sample bottle from storage.
- 11.11. Extrude the sediment core(s) from the liner tube(s). The sampler pushes the extruder up into the core barrel (1/2-cm at a time).
- 11.12. The sampler opens the sample bottle, scrapes the extruded sediment sample into the sample container and collects sufficient sediment volume for all analyses that are outlined in the workplan. If sediment is needed from a specific depth, then multiple samples may need to be collected to acquire sufficient sample volume. The other sampler closes the sample bottle lid and places the sample back into the sample cooler.
- 11.13. Once the 2 cm layer or desired sample interval has been extruded, discard the used sample core.
- 11.14. Repeat from 11.7 with the other sediment cores from a given sampling location until enough sediment has been collected for all analyses, or until all cores have been extruded. Some cores will self-extrude during this process. If the fine material at the sediment/water interface is lost, discard that core. The deeper material could bias the sample results.
- 11.15. Collect ancillary field measurements (depth, pH, dissolved oxygen, temperature, specific conductance) after sediment samples have been collected. The sampling crew should not disturb the sediments while collecting ancillary data. When wading, this should be done in an area immediately downstream of, or away from the sampling site.

## **12. Calculations Not Applicable**

## **13. Applicable Forms**

Field Data Form for Sediment Sampling

Field Audit for Surface Water Sampling

Audit Finding Record

Photograph Log

**ELM CONSULTING, L.L.C.**  
 600 Hart Road, Suite 130  
 Barrington, IL 60010

## Sediment Sampling Field Data Sheet

Project Description		Field Team Leader	
Project No.	Date	Time	
Sampling Personnel			
Sample ID			
Description of Sample Location & Observations			
Sunny <input type="checkbox"/>	Partly Sunny <input type="checkbox"/>	Cloudy <input type="checkbox"/>	Raining <input type="checkbox"/>
Calm <input type="checkbox"/>	Slightly Windy <input type="checkbox"/>	Windy <input type="checkbox"/>	Gusting Winds <input type="checkbox"/>
Ambient Air Temperature (°F): _____			
Specific conductance (µmhos)		Water temperature (°C)	
pH		Dissolved oxygen (mg/L)	
Sediment samples collected (check)			
	priority pollutant metals		Individual Metal _____
	Skinner List of Inorganics		Individual Metal _____
	total organic carbon		Individual Metal _____
	Individual Metal _____		Other _____
	Individual Metal _____		Other _____
Comments			



600 Hart Road, Suite 130

Barrington, Illinois 60010

### Audit Checklist for Sediment Sampling

Project Description	Field Team Leader
Project No.	Audit Date
Sampling personnel	Audit No.

Audit Question	S	U	N/A	comments
Were all personnel briefed on their assignment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Did the crew have all the forms and maps, equipment and materials necessary to complete the assigned tasks?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were the sampling locations correctly identified on the forms?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were the field meters properly calibrated?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were samples collected according to the procedure and all potential interferences addressed before sampling?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Was the depth of the sediment samples consistent?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were sample locations properly marked for the survey crew?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were the sampling equipment and meter probes properly cleaned between sample locations?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were all sample containers properly labeled?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were all sample containers properly filled (e.g. no head space)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were all samples properly packed for shipping?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
packed in ice?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
custody seals in appropriate places?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Did personnel adhere to the safety procedures?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Auditor Signature: \_\_\_\_\_



600 Hart Road, Suite 130

Barrington, Illinois 60010

**Audit Finding Report**

Project No.	Task No.	Audit No.	Audit Date
Individual(s) contacted		Auditor Signature	
Requirements			
Findings			
Recommended Corrective Action			
Scheduled Response Date		Responsible for Corrective Action	
Corrective Action Taken			
Date	Submitted by	Management Approval	
Date Response Received		Response Acceptable?	Yes No
Reason for Rejection			
Verification			
Date Verified		Auditor Signature	

**ELM** CONSULTING, L.L.C.  
 600 Hart Road, Suite 130  
 Barrington, Illinois 60010

### Photograph Log

Project Description		Field Team Leader	
Project No.	Task No.	Photos By	
Date(s)		Location	
Film Type		Roll/Disk #	of
Frame	Subject/Sample ID	Frame	Subject/Sample ID
1		19	
2		20	
3		21	
4		22	
5		23	
6		24	
7		25	
8		26	
9		27	
10		28	
11		29	
12		30	
13		31	
14		32	
15		33	
16		34	
17		35	
18		36	



## **Standard Operating Procedure (#99-0034-SOP-03) for Collecting Freshwater Fishes for the Purposes of Tissue Analysis in the State of Missouri**

### **1. Scope & Summary**

This standard operating procedure (SOP) outlines techniques for collecting freshwater fishes in lotic environments (i.e., rivers and streams) for the purposes of tissue analysis.

This SOP can be followed when using backpack, and boat electrofishing techniques to collect fish. This SOP is not designed for electrofishing using an electric seine net.

### **2. Reference Documents**

Hughes, R.M., and J.R. Gammon. 1987. Longitudinal changes in fish assemblages and water quality in the Willamette River, Oregon. *Trans. Am. Fish. Soc.*

IEPA (1994) *Quality Assurance Project Plan - Integrated Water Monitoring Program Document*. Section G. Bureau of Water - Division of Laboratories. Springfield, IL.

MDC (2001) *DRAFT Resource Assessment and Monitoring: Standard Operation Procedures - Fish Sampling*. Missouri Department of Conservation - Division of Fisheries. Columbia, MO.

USEPA (2000) *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories-Volume1, Fish Sampling and Analysis, Third Edition*. EPA 823-B-00-007. Office of Water, Fish and Wildlife Contamination Program

### **3. Significance and Use**

The ultimate purpose of this SOP is to provide a framework for the collection, preserving, and shipping of freshwater fishes to an analytical laboratory for analysis. The results of the analyses are to eventually be used for ecological risk assessment. Therefore, the importance of sample integrity cannot be understated. The quality assurance/quality control measures outlined in this SOP become the priority when developing the sampling regime.

To some extent, the fish collection techniques of this SOP follow the draft guidelines established by the Missouri Department of Conservation (MDC) and the techniques used in the Fisheries Division. These techniques evolved from a statewide bioassessment program that would establish a baseline of current conditions of Missouri's aquatic resources and allow the MDC to determine the effectiveness of the management programs and seriousness of environmental threats. As a result of the need to establish this "baseline of current conditions", the concept of Resource Assessment and Monitoring (RAM) was conceived. To achieve RAM goals and objectives, the MDC, along with the Missouri Department of Natural Resources, developed a draft Standard Operating Procedure manual for the fish sampling component of MDC's RAM program (MDC, 2001). Aspects of this SOP follow MDC's draft Standard Operating Procedure manual. Because the MDC manual is in draft form during the writing of this SOP, general fish collection techniques will be utilized in the field as described hereafter. Methods described in the MDC manual will be employed where applicable. Once the MDC manual is reviewed and accepted by state agencies, a revised ELM SOP for conducting fish surveys in the State of Missouri using accepted MDC protocols will be written.

Because the quality control issues become significant when sampling fish for tissue analysis, this SOP largely follows the protocols outlined in USEPA, 2000 which describes fish collection techniques to use for the purpose of tissue analysis for the ultimate goal of developing fish advisory mandates. The USEPA protocols provide guidance with regard to quality assurance/quality control measures while sampling to assure the sampler that the fish tissues that arrive to the laboratory are acceptable for analysis.

#### **4. Potential Interferences**

Inclement weather (i.e., heavy rain, lightning, strong winds) may potentially interfere with assessment activities. Fish sampling procedures should only be conducted in fair weather so that the investigators are not exposed to dangerous conditions. Also, backpack shockers may malfunction in rainy conditions because of the equipment's exposure to moisture in moisture-sensitive areas.

- 4.1. Rapid flow conditions may potentially interfere with assessment activities. Fish sampling procedures should be conducted in preferably low flow conditions so that the investigators can properly collect fish without the fear of losing footing while wading. Also, rapid flow conditions will not allow for proper operation of a boat while electrofishing.
- 4.2. High water in the area of the assessment will interfere with fish sampling procedures and will not be representative of true site-specific conditions. High water will not allow the investigators to properly sample for fish because increase water levels will provide escape routes, stunned fish may never be seen and samplers may not be able to sample a particular pool because it is too deep to wade.
- 4.3. Locally modified sites, such as small impoundments and bridge areas should be avoided unless data are needed to assess the effects of these structures. Whenever possible, the reach should be sampled sufficiently upstream of any bridge or road crossing to minimize the hydrological effects on overall habitat quality. Sampling near the mouths of tributaries entering large waterbodies should also be avoided since these areas will have habitat more typical of the larger waterbody.
- 4.4. Atypical conditions, extreme low flow conditions, excessive turbidity or turbulence, heavy rain, drifting leaves, or other unusual circumstances that affect sampling efficiency, should be avoided.
- 4.5. Loss of contaminants already present in fish tissues can be prevented in the field by ensuring that the skin on fish specimens has not been lacerated by sampling gear.
- 4.6. Once the samples have reached the laboratory, further care must be taken during thawing (if specimens are frozen) to ensure that all liquids from the thawed specimens are retained with the tissue sample as appropriate.
- 4.7. To avoid cross-contamination, field crews should be aware of fish coming into contact with sampling gear (that has not been decontaminated), grease from winches or cables, spilled engine fuel (gasoline or diesel), engine exhaust, dust, ice chests, and ice used for cooling.
- 4.8. All utensils or equipment that will be used directly in handling fish should be cleaned in the laboratory prior to each sampling trip and/or

decontaminated in the field after each use. The composition of the sampling equipment that comes into direct contact with the fish while processing fish will be dependent upon the contaminants of potential concern (COPCs). Prior to fish analysis, the COPCs should be well established through a screening process. Once the samplers know the COPCs, the type of sampling equipment can be acquired. For example, metallic measuring boards, scales and calipers should not be used to process fish being submitted to the laboratory for metals analysis. Additionally, items should not be made of plastic if the fish being submitted to the laboratory are being analyzed for volatile/semi-volatile organic compounds. The type of decontamination media also plays an important role in quality control matters. Alconox or equivalent type of detergent typically works well to decontaminate sampling gear. However, prior to collection, the sample crew should ask the laboratory what media is acceptable to decontaminate equipment.

- 4.9. One aspect of sample collection that is of paramount importance is that the sampling team must ensure the collection of live, intact fish for use in sample analysis for ecological risk assessment. It is highly desirable to collect live, intact fish that have not been mutilated by the collection gear and that do not have any skin lacerations or fin deterioration that would allow body fluids to leak out of the specimen or contaminants to pass into the specimen after collection. For example, some fish collected by electroshocking methods may have ruptured organs due to the electroshocking procedure. Fish that are found floating dead at a site should not be used for sample analysis for ecological risk assessments. The USEPA recommends that any specimens that show any skin lacerations or fin deterioration of any kind not used for chemical analysis.
- 4.10. It is recommended by the MDOC that fish be sampled between 1 June and 15 September when stream flows are generally low, pollution stresses are potentially greatest and the fish community is most stable and sedentary (MDOC, 2001). If attempts are made to collect fish other than in this time interval, low yields could result as well as representative site conditions may not be present.
- 4.11. Ideally, fish specimens should not be frozen prior to resection if analyses will include edible tissue (fillets) only because freezing may cause some internal organs to rupture and contaminate fillets or other edible tissues.

## 5. Apparatus

Backpack electrofishing units are small, portable devices carried on the back of one person using a backpack frame. Both A.C. and D.C. units are available; however, the commonly used battery powered, Smith-Root D.C. unit is the most effective in waters of moderate conductivity. Direct current is charged successively to low voltage alternating current by a vibrator, to high voltage direct current by a rectifier. The cathode is dragged behind the operator while the loop anode is attached to the end of a fiberglass pole held by the individual carrying the backpack unit. This unit works well in narrow streams less than three feet deep and requires a crew of two to three; one individual to carry the electrofishing unit and one to net fish and carry the bucket. Netting material attached to the anode loop allow the operator to pick up fish. In brush/debris or undercut bank areas, the anode is usually turned off until placed in the cover, then activated, inducing electrotaxis, pulling the fish into open water where they can be netted.

The alternating current boat shocker consists of a motorized boat in which a gasoline-powered generator is mounted to provide an electrical current to three electrodes suspended in the water from bow mounted fiberglass booms. A direct current boat shocker consists of a generator coupled with a power control unit to provide variable electrical current between anode electrodes suspended from bow mounted booms and the cathode electrodes suspended off the gunwale of the boat.

## **6. Materials**

- Backpack electrofishing units and accessories;
- Electrofishing boat and accessories;
- Generator;
- Rubber gloves;
- Waders
- Dip nets;
- Seine nets;
- 5-gal buckets;
- Fish identification keys;
- Fish sampling field data sheets;
- Fish sampling protocols;
- Measuring tape;
- Preservation jars;
- 10% formaldehyde;
- Fish measuring board (plastic or metallic depending on COPCs);
- Balance (gram scale);
- Polarized sunglasses;
- Pencils/waterproof pens;
- PFD;
- Metal clipboard;
- Digital camera/disks or camera/film;
- Calculator;
- Insect repellant;
- Sunscreen;
- Gasoline and can;
- First Aid Kit;
- Block net;
- Earplugs;
- Oars;
- Maps of sampling areas;
- Field logbook;
- Sample request forms;
- Specimen identification labels;
- Chain-of-Custody forms and COC labels;
- Holding trays;
- Calipers (plastic or metallic depending on COPCs);
- Dry ice;
- Freezer tape;
- String;
- Several sizes of plastic bags for holding individual or composite samples;
- Wet Ice;
- Ice chests;
- Duct tape;
- Decontamination equipment (Alconox or equivalent, brushes, etc).

## 7. Hazards & Precautions

- 7.1. The investigator should avoid performing fish sampling procedures when inclement weather conditions are present such as thunder and lightning, strong winds, heavy rain and associated high water. Dangerous weather conditions increase the risk of electrocution, falling limbs and drowning.
- 7.2. The investigator should avoid performing fish sampling procedures when rapid flow conditions are present. Fish sampling procedures are often conducted while wading and rapid flow conditions could potentially cause the investigator to lose footing and be swept away by the current resulting in possible drowning. Also, a boat could become unstable and difficult to maneuver in rapid flow conditions.
- 7.3. The following guidelines are general safety procedures to be practiced when using any type of electrofishing:
  - Never touch an electrode;
  - Never touch the water near an electrode;
  - Never electrofish alone or with an inadequate crew (a sufficient number of crew members, as directed by the fisheries biologist, should be available to perform electrofishing activities);
  - Never electrofish using faulty or damaged components;
  - Never use a dip net with a conductive handle;
  - A well equipped first aid kit should be available at all times;
  - It is recommended every person involved with electrofishing be first aid trained biennially and CPR trained on an annual basis.
- 7.4. Exhaust from gasoline powered engines should be directed away from the equipment operator and exposed hot pipes should be enclosed in protective screening to reduce the potential of burn exposure to crew members.
- 7.5. Gasoline should be stored and transported in approved metal or plastic containers.
- 7.6. To refuel backpack shockers, all equipment should be turned off. Hot surfaces should be allowed to cool.
- 7.7. Electrode handles should be constructed of a nonconductive material and be of sufficient length to avoid hand contact with the water.
- 7.8. The positive electrode (anode) with portable electroshockers should be equipped with a pressure switch that breaks the electric current upon release.
- 7.9. Netters should work beside or behind the individual with the electrofishing equipment to ensure that electrical field is well in front of both workers.
- 7.10. All persons using portable electroshockers should wear rubber footwear, which will insulate the wearer from electrical shock. All footwear should be equipped with nonslip soles.
- 7.11. Rubber linesman gloves, rated above the voltage being used in the electrofishing operation, should be worn. These gloves should be inspected for punctures before each use and should be replaced at adequate intervals.

- 7.12. Polarized sunglasses should be worn when there is glare.
- 7.13. Batteries used as electrical power source for backpack shockers should be of the gel type that will not leak when tipped or overturned.
- 7.14. Backpacks should be equipped with a quick release belt (hip) and shoulder straps.
- 7.15. The operator should have a switch to the pulsator or power control unit so that the electricity can be turned off quickly in an emergency.
- 7.16. All equipment purchased after October 1, 1985, should be equipped with a tilt switch that breaks the circuit if the operator falls. The switch must be a type that has to be manually reset after the operator has regained his/her footing.
- 7.17. All persons should wear U.S. Coast Guard approved personal flotation devices (Type II) (i.e., life jackets or float coats) when operating in waters that are deep, high velocity, or turbid, to prevent drowning.
- 7.18. All persons should be aware of the hazards involved in using portable backpack shockers in running waters such as slippery surfaces, swift water currents, deep areas, and obstacles such as logs or similar objects.
- 7.19. Noise levels should be maintained within the acceptable exposure of 85 dba for 8-hour exposure. Personal protective measures, such as use of earplugs, are recommended.
- 7.20. Instruction sheets for equipment, and operational procedures should be enclosed in waterproof plastic and be readily available for reference at all times during the electrofishing operation.
- 7.21. All equipment used in electrofishing should be scheduled for an annual preventative maintenance inspection. In addition, all equipment should be inspected before each use. Any equipment deficiency which may present a safety hazard will be corrected before each field operation or when equipment damage occurs during actual use.
- 7.22. Boat Electrofishing Safety Guidelines
  - 7.22.1. Electrofishing boats will provide adequate flotation and freeboard clearance consistent with equipment cargo, and passenger weight when being operated. The boat will be equipped to meet U.S. Coast Guard or State boating regulations. The boat deck will be painted with a nonslip or skid resistant coating.
  - 7.22.2. General boat housekeeping must provide adequate working space to conduct safe operations. Care will be exercised to prevent clutter that may result in safety hazards from building up.
  - 7.22.3. The boat and equipment will be visually inspected for safety by the supervisor or operator in charge prior to each use. Significant deficiencies, which could result in employee injury, will be corrected prior to operation or use of the equipment.

7.22.4. Electrical amp-volt meters will be installed to provide adequate monitoring of boat electrical power equipment. The boat operator should be able to operate an electrical control or switch to cut the power in case of an accident. The will have a deadman switch connected to the power control circuit from the pulsator or generator source. This allows the current between the electrodes to be broken in case of an accident. Power control circuits will not exceed 24 volts.

7.22.5. All metal surfaces within a metal boat will be electrically connected, grounded, and bonded to the boat hull to eliminate differences in electrical potential that may result in electric shock. The metal boat hull may also be used as a cathode. To avoid possible electrolysis problems when the metal hull is being used as a cathode, zinc strips should be attached to the hull as "sacrificial anodes". The electrolysis will occur on the zinc strips, which will preserve the integrity of the hull.

7.22.6. An acid proof, nonmetallic enclosure and holder will be provided for wet cell batteries.

7.22.7. All conductors may be installed in a common raceway (conduit) provided each conductor installed is continuous (without connectors, breaks, or splicing), is independently and correctly insulated. All low voltage (24 volts or less) circuits will be contained in separate raceways from those containing high voltage conductors.

7.22.8. Lighting and other auxiliary circuits should not exceed 24 volts. Note: 110-volt lamps may be used if the lamp is shielded with a nonconductive cage.

7.22.9. When the boat is to operated at night, adequate on-board lighting will be provided for working areas (such as battery powered lanterns). Adequate lighting will also be provided while electrofishing to avoid safety hazards such as striking logs, rocks, and overhead tree branches.

7.22.10. Each boat will be equipped with at least one 5-pound type ABC fire extinguisher mounted in a holder for easy access to the boat operator and away from high fire potential sources.

7.22.11. All occupants will wear U.S. Coast Guard approved personal flotation devices at all times. Life vests that meet the requirements of Type II are designed to turn an unconscious person in the water from a face downward position to a vertical or slightly backward position. Float coats may be provide some protection against the loss of body head if the person were accidentally fall into cold water.

7.22.12. Hip boots or chest waders should be worn. Hip boots are easier to remove if you fall overboard or the boat capsizes. Chest waders provide better protection against possible electrical shock. Rubber

gloves should be worn that are rated above the voltage being used. These should be inspected before each use and replaced at adequate intervals. Ear plugs or earphones should be worn by the netter and boat operator.

## **8. Procedure**

### **8.1. Fish Sampling Procedures Using Backpack Shockers**

The following description outlines protocols to use in wadeable streams.

- 8.1.1. Identify the sample location from the sampling map. The sample location selected should historically yield the species and size of fish that will achieve project goals. Prior to sampling, the sampling crew should acquire as much site-specific data about the fisheries as possible so that samples yields will not be in vain.
- 8.1.2. Determine the field crew size by assessing the size of the sampling reach prior to collection. A minimum 2-person fisheries crew will be needed to sample for fish using the backpack electrofishing technique.
- 8.1.3. Evaluate all sampling gear (backpack shockers, nets, etc.) to insure that all equipment is functioning properly. Decontaminate all materials used to collect or come into contact with sampled fish (nets, buckets, measuring boards, calipers, etc).
- 8.1.4. The sampling crew should enter the stream and space themselves as to cover as much habitat as possible. Ideally, there will be enough field personnel to stretch from one bank to another to cover the width of the stream.
- 8.1.5. Activate the backpack shockers and proceed upstream attempting to sample all areas of the stream. The sampling crew uses a side-to-side or bank-to-bank sweeping technique to maximize area coverage. Sampling of most species is most effective near shore and cover (macrophytes, boulders, snags, and brush). If the sampling crew is collecting a specific species, then the crew can simply net that species when shocked. If the type of fish collected is irrelevant, then all fish that are stunned should be netted and deposited into the decontaminated 5-gallon buckets for processing.
- 8.1.6. Continue the sampling process until the desired quantity of fish is collected.
- 8.1.7. Once the sampling has concluded, choose an open area along the bank of the water body to begin the processing of fish.
- 8.1.8. Complete a "Field Record for Fish Contaminant Monitoring Program" for each sampling event.

8.1.9. Species may be separated into adults and juveniles by size and coloration. Using only decontaminated sampling equipment, record total numbers, lengths (maximum body length), weights, sex and the incidence of external anomalies for each group. Species of special concern (e.g., threatened, endangered) should be noted and released immediately on site. Observations such as eroded fins, poor condition, excessive mucous, fungus, external parasites, reddening, lesions, and tumors on the fish should be noted. Reference, or voucher specimens of unusual species from each site are preserved in 10 percent formaldehyde, the jar labeled, and the collection placed with the state ichthyological museum to confirm identifications and to constitute a biological record. This is especially important for uncommon species, for species requiring laboratory identification, and for documenting new distribution records.

8.1.10. At the conclusion of processing for each fish, the fish chosen for analysis should be individually double-bagged into a heavy-duty "zip-lock" type polyethylene bag. Spines on fish should be sheared to minimize punctures in the bag. Fish chosen for analysis should be based on project goals and requirements outlined in the work plan.

8.1.11. The sample identification label should be completed and taped to the outside of each double "zip-lock" bag.

8.1.12. The COC tag or label should be completed and attached to the outside of the double "zip-lock" bag with string or tape. Once bagged correctly, samples should be cooled on ice immediately.

8.1.13. Shipping requirements: Wet ice or blue ice (sealed prefrozen ice packets) is recommended as the preservative of choice when the **fish fillets** are the primary tissues to be analyzed. Samples shipped on wet or blue ice should be delivered to the processing laboratory within 24 hours. If the shipping time to the processing laboratory will exceed 24 hours, dry ice should be used. If **whole fish** are to be analyzed, either wet ice, blue ice, or dry ice may be used; however, if the shipping time to the processing laboratory will exceed 24 hours, dry ice should be used. **Be aware that dry ice requires special packaging precautions before shipping by aircraft to comply with U.S. Department of Transportation regulations. Check with the shipper and 49 CFR 173.217 for packaging and shipping information when shipping dry ice.**

## 8.2. Fish Sampling Procedures Using the Boat Electrofishing Technique

8.2.1. Identify the sample location from the sampling map. The sample location selected should historically yield the species and size of fish that will achieve project goals. Prior to sampling, the sampling crew should acquire as much site-specific data about the fisheries as possible so that samples yields will not be in vain.

- 8.2.2. Evaluate all sampling gear (shocking equipment, generator, nets, etc.) to insure that all equipment is functioning properly.
- 8.2.3. The boat is slowly driven upstream starting at the most downstream end of the sampling reach through shallow near shore areas, alongside or in weed beds and/or brush, while one or two assistants stand on the bow platform to collect shocked fish using  $\frac{1}{4}$  mesh dip nets. Periodically the operator may see shocked fish surfacing behind the boat, wherein he may turn around with the electrical current off to collect them.
- 8.2.4. The operator may also circle the boat around attractive cover, such as submerged brush or timber. Once collected, the fish should be placed in a large aerated holding tank with sample water in order to minimize stress until the sampling run is completed and the fish can be processed.
- 8.2.5. At this point, the sampling crew can follow the same instructions outlined in Sections 8.1.6-8.1.12.

**9. Applicable Forms**

- Field Record for Fish Contaminant Monitoring Program;
- Sample Identification Label;
- Chain-of-Custody Label or Tag;
- Photograph Log.

## Field Record for Fish Contaminant Monitoring Program

Project Number:			Sampling Date and Time:		
<b>SITE LOCATION</b>					
Site Name/Number:					
County/Parish:			Lat./Long.		
Waterbody Name/Segment No.					
Waterbody Type:			<input type="checkbox"/> RIVER <input type="checkbox"/> LAKE <input type="checkbox"/> ESTUARY		
Site Description:					
Collection Method:					
Collector Name: (print and sign)					
Agency/Company:				Phone: (    )	
Address:					
<b>FISH COLLECTED</b>					
Bottom Feeder-Species Name:					
Composite Sample #			Number of Individuals:		
Fish #	Length (mm)	Sex	Fish #	Length (mm)	Sex
001			006		
002			007		
003			008		
004			009		
005			010		
Maximum size Minimum size X 100 = _____ ≥ 75%			Composite mean length _____ mm		
Notes: (e.g. morphological anomalies):					
Predator-Species Name:					
Composite Sample #			Number of Individuals:		
Fish #	Length (mm)	Sex	Fish #	Length (mm)	Sex
001			006		
002			007		
003			008		
004			009		
005			010		
Maximum size Minimum size X 100 = _____ ≥ 75%			Composite mean length _____ mm		
Notes: (e.g. morphological anomalies):					

Taken from USEPA, 2000

**Example of a Sample Identification Label**

Species Name or Code		Sample Type	
Total Length or Size (mm)	Sampling Site (name/number)		
Specimen Number		Sampling Date (YYMMDD)	Time (24-h clock)

**Example of a Chain-of-Custody Tag or Label**

Project Number		Name of Collection Company or Agency	
Sampling Site (name and/or ID number)		Sampler (name and signature)	
Composition Number/Specimen Number(s)		Sampling Date (YYYYMMDD):	
		Sampling Time (24-h clock):	
Processing: Whole body or resection		Type of Ice: Wet or Dry	
Species Name or Code		Chemical Analysis: <input type="checkbox"/> All target analytes <input type="checkbox"/> Others (specify): _____ _____ _____ _____	
Comments			



## **Standard Operating Procedure (#99-0034-SOP-04) for Conducting an Index of Biotic Integrity Survey in the State of Missouri**

### **1. Scope & Summary**

This standard operating procedure (SOP) outlines techniques for conducting an Index of Biotic Integrity Survey (IBI) in lotic environments (i.e., rivers and streams) in the State of Missouri.

This SOP can be followed when using backpack and boat electrofishing techniques to collect fish. This SOP is also designed to outline techniques to utilize while collecting fish with a seine net.

### **2. Reference Documents**

Hughes, R.M., and J.R. Gammon. 1987. Longitudinal changes in fish assemblages and water quality in the Willamette River, Oregon. *Trans. Am. Fish. Soc.*

IEPA (1994) *Quality Assurance Project Plan - Integrated Water Monitoring Program Document*. Section G. Bureau of Water - Division of Laboratories. Springfield, IL.

Karr, J.R., D.D. Fausch, P.L. Angermeier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters: A method and its rationale. *Special Publication 5. Illinois Natural History Survey*.

MDC (2001) *DRAFT Resource Assessment and Monitoring: Standard Operation Procedures - Fish Sampling*. Missouri Department of Conservation - Division of Fisheries. Columbia, MO.

### **3. Significance and Use**

This SOP is largely based on draft guidelines established by the Missouri Department of Conservation (MDC) and the techniques used in the Fisheries Division. These techniques evolved from a statewide bioassessment program that would establish a baseline of current conditions of Missouri's aquatic resources and allow the MDC to determine the effectiveness of the management programs and seriousness of environmental threats. As a result of the need to establish this "baseline of current conditions", the concept of Resource Assessment and Monitoring (RAM) was conceived. To achieve RAM goals and objectives, the MDC, along with the Missouri Department of Natural Resources, developed a draft *Standard Operating Procedure* manual for the fish sampling component of MDC's RAM program (MDC, 2001). Aspects of this SOP follow MDC's draft *Standard Operating Procedure* manual. Because the MDC manual is in draft form during the writing of this SOP, general IBI protocols will be utilized in the field as described hereafter. Methods described in the MDC manual will be employed where applicable. Once the MDC manual is reviewed and accepted by state agencies, a revised ELM SOP for conducting fish surveys in the State of Missouri using accepted MDC protocols will be written.

IBI procedures described in this SOP are also based on Karr's IBI which uses fish community structure to evaluate stream quality. The IBI is a broadly based index firmly grounded in fisheries community ecology. The IBI incorporates zoogeographic, ecosystem, community, population, and individual perspectives. It can accommodate natural differences in the distribution and abundance of species that result from differences in waterbody size, type, and region of occurrence. Use of the IBI allows

national comparisons of biological integrity without the traditional bias for small coldwater streams (e.g., a salmon river in Alaska and a minnow stream in Georgia both could be rated excellent if they were comparable to the best streams expected in their respective regions).

Karr et al. (1986) provided a consistent theoretical framework for analyzing fish community data. The IBI uses 12 biological metrics to assess integrity based on the fish community's taxonomic and trophic composition and the abundance and condition of fish. Such multiple-parameter indices are necessary for making objective evaluations of complex systems. The IBI was designed to evaluate the quality of small mid-western streams, but has been modified for use in many regions of the country and in large rivers. The 12 biological metrics are as follows:

- Total number of fish species;
- Number and identity of darter species;
- Number and identity of sunfish species;
- Number and identity of sucker species;
- Number and identity of intolerant species;
- Proportion of individuals as green sunfish;
- Proportion of individuals as omnivores;
- Proportion of individual which are insectivorous cyprinids;
- Proportion of individuals as top carnivores;
- Fish abundance and condition metrics;
- Number of individuals in sample;
- Proportion of individuals as hybrids; and
- Proportion of individuals with disease, tumors, fin damage, and skeletal anomalies.

The metrics attempt to quantify an ichthyologist's best professional judgement of the quality of the fish community. The IBI utilizes professional judgment, but in a prescribed manner and it includes quantitative standards for discriminating fish community condition. Judgment is involved in choosing the most appropriate population or community element that is representative of each metric and in setting the scoring criteria. This process can be easily and clearly modified, as opposed to judgments that occur after results are calculated. Each metric is scored against criteria based on expectations developed from regionally derived "maximum species richness" regressions; these may or may not reflect species present in an actual "reference" site or stream. Metric values approximating, deviating slightly from, or deviating greatly from values derived from regional expectations are scored as 5, 3, or 1, respectively. The scores of the 12 metrics are added for each station to give an IBI of 60 (excellent) to 12 (very poor) (See "Flowchart of Biosurvey Approach for Fish Bioassessment - IEPA, 1994).

#### **4. Potential Interferences**

- 4.1. Inclement weather (i.e., heavy rain, lightning, strong winds) may potentially interfere with assessment activities. IBI procedures should only be conducted in fair weather so that the investigators are not exposed to dangerous conditions and so that IBI scores are not influenced by temporary weather changes. Also, backpack shockers may malfunction in rainy conditions because of the equipment's exposure to moisture in moisture-sensitive areas.
- 4.2. Rapid flow conditions may potentially interfere with assessment activities. IBI procedures should be conducted in preferably low flow conditions so that the investigators can properly collect fish without the fear of losing

footing while wading. Also, rapid flow conditions will not allow for proper operation of a boat while electrofishing.

- 4.3. High water in the area of the assessment will interfere with IBI procedures and will not be representative of true site-specific conditions. High water will not allow the investigators to properly sample for fish because increase water levels will provide escape routes, stunned fish may never be seen and samplers may not be able to sample a particular pool because it is too deep to wade.
- 4.4. Locally modified sites, such as small impoundments and bridge areas should be avoided unless data are needed to assess the effects of these structures. Whenever possible, the reach should be sampled sufficiently upstream of any bridge or road crossing to minimize the hydrological effects on overall habitat quality. Sampling near the mouths of tributaries entering large waterbodies should also be avoided since these areas will have habitat more typical of the larger waterbody.
- 4.5. Atypical conditions, extreme low flow conditions, excessive turbidity or turbulence, heavy rain, drifting leaves, or other unusual circumstances that affect sampling efficiency, should be avoided.

## 5. Apparatus

Backpack electrofishing units are small, portable devices carried on the back of one person using a backpack frame. Both A.C. and D.C. units are available; however, the commonly used battery powered, Smith-Root D.C. unit is the most effective in waters of moderate conductivity. Direct current is charged successively to low voltage alternating current by a vibrator, to high voltage direct current by a rectifier. The cathode is dragged behind the operator while the loop anode is attached to the end of a fiberglass pole held by the individual carrying the backpack unit. This unit works well in narrow streams less than three feet deep and requires a crew of two to three; one individual to carry the electrofishing unit and one to net fish and carry the bucket. Netting material attached to the anode loop allow the operator to pick up fish. In brush/debris or undercut bank areas, the anode is usually turned off until placed in the cover, then activated, inducing electrotaxis, pulling the fish into open water where they can be netted.

The alternating current boat shocker consists of a motorized boat in which a gasoline-powered generator is mounted to provide an electrical current to three electrodes suspended in the water from bow mounted fiberglass booms. A direct current boat shocker consists of a generator coupled with a power control unit to provide variable electrical current between anode electrodes suspended from bow mounted booms and the cathode electrodes suspended off the gunwale of the boat.

## 6. Materials

- Backpack electrofishing units and accessories;
- Electrofishing boat and accessories;
- Generator;
- Rubber gloves;
- Waders
- Dip nets;
- 5-gal buckets;
- Fish identification keys;
- Fish sampling field data sheets;

- Fish sampling and IBI protocols;
- Measuring tape;
- Fish measuring board;
- Balance (gram scale);
- Polarized sunglasses;
- Pencils/waterproof pens;
- 10% formalin solution for preservation;
- PFD;
- Metal clipboard;
- Digital camera/disks or camera/film;
- Calculator;
- Insect repellent;
- Sunscreen;
- Gasoline;
- First Aid Kit;
- Jars for preservation;
- Labels;
- Block net; and
- Earplugs.

## **7. Hazards & Precautions**

- 7.1. The investigator should avoid performing IBI procedures when inclement weather conditions are present such as thunder and lightning, strong winds, heavy rain and associated high water. Dangerous weather conditions increase the risk of electrocution, falling limbs and drowning.
- 7.2. The investigator should avoid performing IBI procedures when rapid flow conditions are present. IBI procedures are conducted while wading and rapid flow conditions could potentially cause the investigator to lose footing and be swept away by the current resulting in possible drowning. Also, a boat could become unstable and difficult to maneuver in rapid flow conditions.
- 7.3. The following guidelines are general safety procedures to be practiced when using any type of electrofishing:
  - Never touch an electrode;
  - Never touch the water near an electrode;
  - Never electrofish alone or with an inadequate crew (a sufficient number of crew members, as directed by the fisheries biologist, should be available to perform electrofishing activities);
  - Never electrofish using faulty or damaged components;
  - Never use a dip net with a conductive handle;
  - A well equipped first aid kit should be available at all times;
  - It is recommended every person involved with electrofishing be first aid trained biennially and CPR trained on an annual basis.
- 7.4. Exhaust from gasoline powered engines should be directed away from the equipment operator and exposed hot pipes should be enclosed in protective screening to reduce the potential of burn exposure to crew members.
- 7.5. Gasoline should be stored and transported in approved metal or plastic containers.

- 7.6. To refuel backpack shockers, all equipment should be turned off. Hot surfaces should be allowed to cool.
- 7.7. Electrode handles should be constructed of a nonconductive material and be of sufficient length to avoid hand contact with the water.
- 7.8. The positive electrode (anode) with portable electroshockers should be equipped with a pressure switch that breaks the electric current upon release.
- 7.9. Netters should work beside or behind the individual with the electrofishing equipment to ensure that electrical field is well in front of both workers.
- 7.10. All persons using portable electroshockers should wear rubber footwear, which will insulate the wearer from electrical shock. All footwear should be equipped with nonslip soles.
- 7.11. Rubber linesman gloves, rated above the voltage being used in the electrofishing operation, should be worn. These gloves should be inspected for punctures before each use and should be replaced at adequate intervals.
- 7.12. Polarized sunglasses should be worn when there is glare.
- 7.13. Batteries used as electrical power source for backpack shockers should be of the gel type that will not leak when tipped or overturned.
- 7.14. Backpacks should be equipped with a quick release belt (hip) and shoulder straps.
- 7.15. The operator should have a switch to the pulsator or power control unit so that the electricity can be turned off quickly in an emergency.
- 7.16. All equipment purchased after October 1, 1985, should be equipped with a tilt switch that breaks the circuit if the operator falls. The switch must be a type that has to be manually reset after the operator has regained his/her footing.
- 7.17. All persons should wear U.S. Coast Guard approved personal flotation devices (Type II) (i.e., life jackets or float coats) when operating in waters that are deep, high velocity, or turbid, to prevent drowning.
- 7.18. All persons should be aware of the hazards involved in using portable backpack shockers in running waters such as slippery surfaces, swift water currents, deep areas, and obstacles such as logs or similar objects.
- 7.19. Noise levels should be maintained within the acceptable exposure of 85 dba for 8-hour exposure. Personal protective measures, such as use of earplugs, are recommended.
- 7.20. Instruction sheets for equipment, and operational procedures should be enclosed in waterproof plastic and be readily available for reference at all times during the electrofishing operation.
- 7.21. All equipment used in electrofishing should be scheduled for an annual preventative maintenance inspection. In addition, all equipment should be inspected before each use. Any equipment deficiency which may present a

safety hazard will be corrected before each field operation or when equipment damage occurs during actual use.

## 7.22. Boat Electrofishing Safety Guidelines

- 7.22.1. Electrofishing boats will provide adequate flotation and freeboard clearance consistent with equipment cargo, and passenger weight when being operated. The boat will be equipped to meet U.S. Coast Guard or State boating regulations. The boat deck will be painted with a nonslip or skid resistant coating.
- 7.22.2. General boat housekeeping must provide adequate working space to conduct safe operations. Care will be exercised to prevent clutter that may result in safety hazards from building up.
- 7.22.3. The boat and equipment will be visually inspected for safety by the supervisor or operator in charge prior to each use. Significant deficiencies, which could result in employee injury, will be corrected prior to operation or use of the equipment.
- 7.22.4. Electrical amp-volt meters will be installed to provide adequate monitoring of boat electrical power equipment. The boat operator should be able to operate an electrical control or switch to cut the power in case of an accident. There will be a deadman switch connected to the power control circuit from the pulsator or generator source. This allows the current between the electrodes to be broken in case of an accident. Power control circuits will not exceed 24 volts.
- 7.22.5. All metal surfaces within a metal boat will be electrically connected, grounded, and bonded to the boat hull to eliminate differences in electrical potential that may result in electric shock. The metal boat hull may also be used as a cathode. To avoid possible electrolysis problems when the metal hull is being used as a cathode, zinc strips should be attached to the hull as "sacrificial anodes". The electrolysis will occur on the zinc strips, which will preserve the integrity of the hull.
- 7.22.6. An acid proof, nonmetallic enclosure and holder will be provided for wet cell batteries.
- 7.22.7. All conductors may be installed in a common raceway (conduit) provided each conductor installed is continuous (without connectors, breaks, or splicing), is independently and correctly insulated. All low voltage (24 volts or less) circuits will be contained in separate raceways from those containing high voltage conductors.
- 7.22.8. Lighting and other auxiliary circuits should not exceed 24 volts. Note: 110-volt lamps may be used if the lamp is shielded with a nonconductive cage.

7.22.9. When the boat is to be operated at night, adequate on-board lighting will be provided for working areas (such as battery powered lanterns). Adequate lighting will also be provided while electrofishing to avoid safety hazards such as striking logs, rocks, and overhead tree branches.

7.22.10. Each boat will be equipped with at least one 5-pound type ABC fire extinguisher mounted in a holder for easy access to the boat operator and away from high fire potential sources.

7.22.11. All occupants will wear U.S. Coast Guard approved personal flotation devices at all times. Life vests that meet the requirements of Type II are designed to turn an unconscious person in the water from a face downward position to a vertical or slightly backward position. Float coats may provide some protection against the loss of body heat if the person were accidentally fall into cold water.

7.22.12. Hip boots or chest waders should be worn. Hip boots are easier to remove if you fall overboard or the boat capsizes. Chest waders provide better protection against possible electrical shock. Rubber gloves should be worn that are rated above the voltage being used. These should be inspected before each use and replaced at adequate intervals. Ear plugs or earphones should be worn by the netter and boat operator.

## 8. Procedure

### 8.1. Fish Sampling Procedures Using Backpack Shockers

8.1.1. Identify the sample location from the sampling map. Both the reference sampling reach and the study sampling reach should be pre-determined using Stream Habitat Assessment Procedures (SHAP) and should be 100-200 yards or 91.44-182.88 meters (See SOP for the Qualitative Stream Habitat Assessment Procedure in Appendix A of the Sampling and Analysis Plan). Determine the field crew size using the information collected during the SHAP. A minimum 2-person fisheries crew will be needed to sample for fish using the backpack electrofishing technique.

8.1.2. Evaluate all sampling gear (backpack shockers, nets, etc.) to insure that all equipment is functioning properly.

8.1.3. No person shall enter the sample reach of the stream until the upper and lower ends of the sample reach are marked and appropriate length block nets have been set. The downstream net should be deployed first from one stream bank to the other. The ends of the block net should be securely fixed to the stream banks so that normal flow and objects such as twigs, logs etc. do not dislodge the net from the bank. Once the downstream block net has been established, the sampling crew should walk upstream overland (not in the stream) and deploy the upstream block net.

- 8.1.4. Sampling begins at a shallow riffle, or other physical barrier at the downstream limit of the sample reach, and terminates at the similar barrier at the upstream end of the reach. In the absence of physical barriers, block nets should be set at the upstream and downstream ends of the reach prior to the initiation of any sampling activities.
- 8.1.5. Activate the backpack shockers and proceed upstream attempting to sample all areas of the stream. The sampling crew uses a side-to-side or bank-to-bank sweeping technique to maximize area coverage. When sampling large streams, rivers, or waterbodies with complex habitats, a complete inventory of the entire reach is not necessary for the level of assessment used in the fish bioassessment. The sampling area should be representative of the reach, incorporating riffles/runs/pools if these habitats are typical of the stream in question. Sampling of most species is most effective near shore and cover (macrophytes, boulders, snags, and brush). The biosurvey is not an exhaustive inventory, but it provides a realistic sample of fishes likely to be encountered in the waterbody. All fish that are stunned should be netted and deposited into the 5-gallon buckets for processing. However, Karr et al. (1986) recommended exclusion of fish less than 20 mm in length and young-of-the-year. This recommendation should be considered on a regional basis and is also applicable to large fish requiring special gear for collection (e.g., sturgeon). The intent of the sample is to obtain a representative estimate of the species present, and their relative abundance, in a reasonable amount of effort.
- 8.1.6. Sample the entire reach until the most upstream marker is identified. A 30-minute sampling effort is desirable.
- 8.1.7. Once the entire reach has been sampled, choose an open area along the bank of the reach to begin the processing of fish. Preferably, the processing area will be downstream of the sampling reach close to the far downstream marker.
- 8.1.8. Complete a "Fish Sampling Data Sheet" (in Appendix A of the Sampling and Analysis Plan) for each sample. Sampling duration and area or distance sampled are recorded to determine level of effort. Species may be separated into adults and juveniles by size and coloration; then total numbers, lengths (total length), weights, and the incidence of external anomalies are recorded for each group. Species of special concern (e.g., threatened, endangered) should be noted and released immediately on site. Observations such as eroded fins, poor condition, excessive mucous, fungus, external parasites, reddening, lesions, and tumors on the fish should be noted. Reference, or voucher specimens of unusual species from each site are preserved in 10 percent formaldehyde, the jar labeled, and the collection placed with the State ichthyological museum to confirm identifications and to constitute a biological record. This is especially important for uncommon species, for species requiring laboratory identification, and for documenting new distribution records.

## 8.2. Fish Sampling Procedures Using the Boat Electrofishing Technique

- 8.2.1. Identify the sample location from the sampling map. Both the reference sampling reach and the study sampling reach should be pre-determined using SHAPs and should be 100-200 yards or 91.44-182.88 meters in length.
- 8.2.2. Evaluate all sampling gear (shocking equipment, generator, nets, etc.) to insure that all equipment is functioning properly.
- 8.2.3. The boat is slowly driven upstream starting at the most downstream end of the sampling reach through shallow near shore areas, alongside or in weed beds and/or brush, while one or two assistants stand on the bow platform to collect shocked fish using ¼ mesh dip nets. Periodically the operator may see shocked fish surfacing behind the boat, wherein he may turn around with the electrical current off to collect them. This should be done at least once every 100 yards during a sampling run.
- 8.2.4. The operator may also circle the boat around attractive cover, such as submerged brush or timber, for a period of approximately 5 minutes. Once collected the fish should be placed in a large aerated and salted holding tank in order to minimize stress until the sampling run is completed and the fish can be processed.

## 8.3. Calculating IBI Values

- 8.3.1. Once a fish sampling data sheet has been completed for each reach under investigation, the investigator should assign species to trophic guild and identify and assign species tolerances. Where published data are lacking, assignments are made based on knowledge of closely related species and morphology (See "Definitions and Trophic Status Designations for Illinois Fish").
- 8.3.2. Develop scoring criteria for each IBI metric. Maximum species richness (or density) lines are developed from a reference database (See "Index of Biotic Integrity Species Richness and Composition Mid-Range Scoring Criteria for Seven Major Illinois Regions" - IEPA, 1994; "Scoring Criteria for Seven Index of Biotic Integrity Metrics That Do Not Vary Regionally in Illinois" - IEPA, 1994; and "List of Intolerant Fish Species of Illinois" - IEPA, 1994).
- 8.3.3. Enumerate and tabulate number of fish species and relative abundances.
- 8.3.4. Summarize site information for each IBI metric.
- 8.3.5. Rate each IBI metric and calculate total IBI score.
- 8.3.6. Interpret data in the context of the habitat assessment. Individual metric analysis may be necessary to ascertain specific trends.

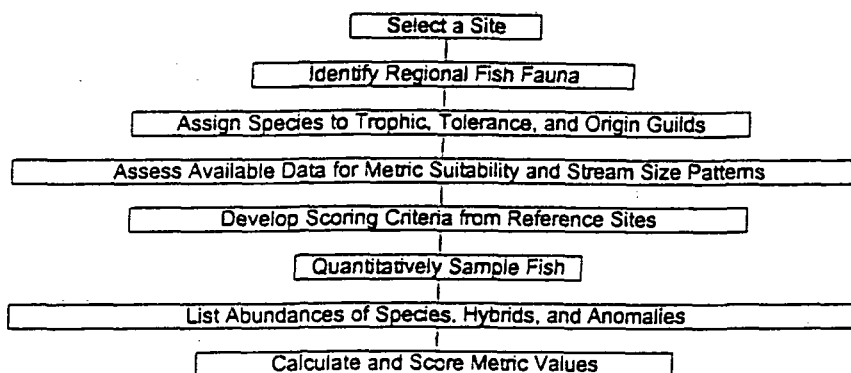
- 8.4. Repeat Sections 8.1 and 8.2 within the reference reach if the study reach was sampled first or vice-versa.

**9. Applicable Forms**

- Fish Collection Field Data Sheet;
- Flowchart of Biosurvey Approach for Fish Bioassessment- IEPA, 1994;
- Definitions and Trophic Status Designations for Illinois Fish- IEPA, 1994;
- Index of Biotic Integrity Species Richness and Composition Mid-Range Scoring Criteria for Seven Major Illinois Regions- IEPA, 1994;
- Scoring Criteria for Seven Index of Biotic Integrity Metrics That Do Not Vary Regionally in Illinois- IEPA, 1994;
- List of Intolerant Fish Species of Illinois- IEPA, 1994; and
- Photograph Log.



**Flowchart of biosurvey approach for Fish Bioassessment  
(taken from IEPA, 1994)**



METRIC SCORES (IBI)			
Metric	Scoring Criteria <sup>(a)</sup>		
	5	3	1
1. Number of native fish species	Expectations for metrics 1-5 vary with stream size and region.		
2. Number and identify of darter species			
3. Number and identify of sunfish species			
4. Number and identify of sucker species			
5. Number and identify of intolerant species			
6. Proportion of individuals as green sunfish	<5%	5-20%	>20%
7. Proportion of individuals as omnivores	<20%	20-45%	>45%
8. Proportion of individuals as insectivorous cyprinids	>45%	45-20%	<20%
9. Proportion of individuals as top carnivores	<5%	5-1%	<1%
10. Number of individuals in sample	Expectations for metric 10 vary with stream size and other factors.		
11. Proportion of individuals as hybrids	0%	>0-1%	>1%
12. Proportion of individuals with disease/anomalies	0-2%	>2-5%	>5%

<sup>(a)</sup> From Hite and Bertrand, 1989.

INDEX SCORE INTERPRETATION <sup>(a)</sup>		
IBI	Integrity Class	Description
51-60	Excellent	Unique aquatic resource.
41-50	Good	Highly valued aquatic resource.
31-40	Fair	Moderate aquatic resource.
21-30	Poor	Limited aquatic resource.
<21	Very Poor	Restricted use aquatic resource,

<sup>(a)</sup> From Hite and Bertrand, 1989

Recommendations

**Definitions and Trophic Status Designations for Illinois Fish**  
**(modified from Karr et al. 1986)**

*(taken from IEPA, 1994)*

**OMNIVORES**

Gizzard shad	<i>Dorosoma cepedianum</i>	Bluntnose minnow	<i>Pimephales notatus</i>
Central mudminnow	<i>Unbra limi</i>	Fathead minnow	<i>Pimephales promelas</i>
Goldfish	<i>Carassius auratus</i>	Bullhead minnow	<i>Pimephales vigilax</i>
Carp	<i>Cyprinus carpio</i>	Blacknose dace	<i>Rhinichthys atratulus</i>
Golden shiner	<i>Notemigonus crysoleucas</i>	Blue sucker	<i>Cycleptus elongatus</i>
Blacknose shiner	<i>Notropis heterolepis</i>	River carpsucker	<i>Carpiodes carpio</i>
Bigmouth shiner	<i>Notropis dorsalis</i>	Quillback	<i>Carpiodes cyprinus</i>
Mimic shiner	<i>Notropis volucellus</i>	Highfin carpsucker	<i>Carpiodes velifer</i>

**INSECTIVOROUS CYPRINIDS**

Silverjaw minnow	<i>Notropis buccata</i>	Ironcolor shiner	<i>Notropis chalybaeus</i>
Silver chub	<i>Macrhybopsis storeriana</i>	Common shiner	<i>Luxilus comutus</i>
Speckled chub	<i>Macrhybopsis aestivalis</i>	Striped shiner	<i>Luxilus chrysocephalus</i>
Hornyhead chub	<i>Nocomis biguttatus</i>	Pugnose minnow	<i>Opsopoeodus emiliae</i>
Emerald shiner	<i>Notropis atherinoides</i>	Redfin shiner	<i>Lythrurus umbratilis</i>
Bigeye shiner	<i>Notropis boops</i>	Spotfin shiner	<i>Cyprinella spiloptera</i>
Spottail shiner	<i>Notropis hudsonius</i>	Red shiner	<i>Cyprinella lutrensis</i>
Rosyface shiner	<i>Notropis rubellus</i>	Steelcolor shiner	<i>Cyprinella whipplei</i>
Sand shiner	<i>Notropis stramineus</i>	Suckermouth minnow	<i>Phenacobius mirabilis</i>
River shiner	<i>Notropis blenniuss</i>	Creek Chub	<i>Semotilus atromaculatus</i>

**TOP CARNIVORES**

American eel	<i>Anguilla rostrata</i>	White bass	<i>Morone chrysops</i>
Spotted gar	<i>Lepisosteus oculatus</i>	Yellow bass	<i>Morone mississippiensis</i>
Longnose gar	<i>Lepisosteus osseus</i>	Rock bass	<i>Ambloplites rupestris</i>
Shortnose gar	<i>Lepisosteus platostomus</i>	Smallmouth bass	<i>Micropterus dolomieu</i>
Bowfin	<i>Amia calva</i>	Largemouth bass	<i>Micropterus salmoides</i>
Skipjack herring	<i>Alosa chrysochloris</i>	White crappie	<i>Pomoxis annularis</i>
Goldeye	<i>Hiodon alosoides</i>	Black crappie	<i>Pomoxis nigromaculatus</i>
Northern pike	<i>Esox lucius</i>	Yellow perch	<i>Perca flavescens</i>
Grass pickerel	<i>Esox americanus</i>	Walleye	<i>Stizostedion vitreum</i>
Channel catfish	<i>Ictalurus punctatus</i>	Sauger	<i>Stizostedion canadense</i>
Flathead catfish	<i>Pylodictis olivaris</i>		

**SUCKER SPECIES**

Includes all catostomids.

**SUNFISH SPECIES**

Includes all *Lepomis*, *Ambloplites*, and *Pomoxis* species

Index of Biotic integrity species richness and composition mid-range scoring criteria for seven major Illinois regions. In scoring the five IBI metrics, species ranges that fall less than or greater than the mid-range criteria (3) are scored as 1 and 5 respectively. (Taken from IEPA, 1994)

SPECIES RANGE AND 3-POINT SCORING CRITERIA BY REGION								
IBI Metric	Stream Order	Northeast	Northwest/Central	Western	Kaskaskia	Southeast	Big Muddy/Saline	Southern
	2	6-10=3	7-13=3	4-7=3	7-13=3	9-16=3	6-10=3	7-13=3
Number of	3	7-12=3	8-15=3	5-9=3	9-16=3	10-18=3	7-13=3	8-15=3
Species	4	8-14=3	10-18=3	7-12=3	10-19=3	11-20=3	8-15=3	10-18=3
	5	9-16=3	11-21=3	8-15=3	11-21=3	12-22=3	10-18=3	11-21=3
	6	10-18=3	12-23=3	9-17=3	13-24=3	13-24=3	11-21=3	12-23=3
	7	11-20=3	14-26=3	11-20=3	14-27=3	14-26=3	12-23=3	14-26=3
	2	2=3	2-3=3	1=3	1=3	2=3	1=3	1=3
	3	2-3=3	2-3=3	1=3	2=3	2-3=3	1=3	2=3
Sucker	4	2-3=3	3-4=3	2=3	2-3=3	2-3=3	2=3	2-3=3
Species	5	3-4=3	3-5=3	2-3=3	2-3=3	3-4=3	2-3=3	2-3=3
	6	3-5=3	3-5=3	2-3=3	3-4=3	3-5=3	2-3=3	3-4=3
	7	3-5=3	4-6=3	3-4=3	3-5=3	3-5=3	3-4=3	3-5=3
	2	1=3	1=3	1=3	1=3	2=3	2=3	2=3
	3	2=3	1=3	1=3	2=3	2-3=3	2-3=3	2-3=3
Sunfish	4	2-3=3	2=3	2=3	2-3=3	2-3=3	2-3=3	2-3=3
Species	5	2-3=3	2-3=3	2-3=3	2-3=3	3-4=3	3-4=3	3-4=3
	6	3-4=3	2-3=3	2-3=3	3-4=3	3-5=3	3-5=3	3-5=3
	7	3-5=3	3-4=3	3-4=3	3-5=3	3-5=3	3-5=3	3-5=3
	2	2=3	1=3	1=3	1=3	2=3	1=3	2-3=3
	3	2-3=3	2=3	1=3	2=3	2-3=3	2=3	2-3=3
Darter	4	2-3=3	2-3=3	2=3	2-3=3	2-3=3	2-3=3	3-4=3
Species	5	3-4=3	2-3=3	2-3=3	2-3=3	3-4=3	2-3=3	3-5=3
	6	3-5=3	3-4=3	2-3=3	3-4=3	3-5=3	3-4=3	3-5=3
	7	3-5=3	3-5=3	3-4=3	3-5=3	3-5=3	3-5=3	4-6=3
	2	2-3=3	2-3=3	1=3	2-3=3	2-3=3	1=3	1-2=3
	3	2-3=3	3-4=3	2=3	2-3=3	3-5=3	1=3	3-4=3
Intolerant	4	3-4=3	3-5=3	2-3=3	2-3=3	4-6=3	2-3=3	3-5=3
Species	5	3-5=3	3-5=3	2-3=3	3-4=3	4-7=3	2-3=3	4-7
	6	3-5=3	4-6=3	3-4=3	3-5=3	5-9=3	2-3=3	5-8=3
	7	4-6=3	4-7=3	3-5=3	3-5=3	6-10=3	3-4=5	5-9=3

**Scoring Criteria for Seven Index of Biotic Integrity Metrics that do not vary Regionally in Illinois (modified from Karr et al. 1986)  
(taken from IEPA, 1994)**

IBI Metric	Scoring Criteria		
	5	3	1
Proportion of Green Sunfish	<5%	5-20%	>20%
Proportion of Omnivores	<20%	20-45%	>45%
Proportion of Insectivorous Cyprinids	>45%	45-20%	<20%
Proportion of Top Carnivores	>5%	5-1%	<1%
Proportion of Hybrids	0%	0-1%	>1%
Proportion Diseased	0%	0-1%	>1%

Number of Individuals in Sample (3-point range)

	<b><u>Stream Order</u></b>	<b><u>Catch per unit effort (CPUE) Number/0.1 Surface Acres</u></b>
Rotenone	1-2	1300-2600
	3	700-1400
	4	400-800
	5	225-425
	6	125-250
	7	75-125

**Number/Hour**

Electrofishing	2	350-700
	3	300-600
	4	250-500
	5	210-420
	6	180-360
	7	150-300

Seining      40-80 Individuals/50ft. Haul

**List of Intolerant Fish Species of Illinois**

(taken from IEPA, 1994)

**HIODONTIDAE**Mooneye *Hiodon tergisus***SALMONIDAE**

Cisco or lake herring *Coregonus artedii*  
 Lake whitefish *Coregonus clupeaformis*  
 Bloater *Coregonus hoyi*  
 Coho Salmon *Oncorhynchus kisutch*  
 Chinook salmon *Oncorhynchus tshawytscha*  
 Rainbow trout *Oncorhynchus mykiss*  
 Round whitefish *Prosopium cylindraceum*  
 Brown trout *Salmo trutta*  
 Brook trout *Salvelinus fontinalis*  
 Lake trout *Salvelinus namaycush*

**ESOCIDAE**Northern Pike *Esox lucius***CYPRINIDAE**

Largescale stoneroller *Camptostoma oligolepis*  
 Mississippi silvery minnow *Hybognathus nuchalis*  
 Bigeye chub *Notropis amblops*  
 Gravel chub *Erimystax x-punctata*  
 River chub *Nocomis micropogon*  
 Pallid shiner *Notropis amnis*  
 Pugnose shiner *Notropis anogenus*  
 Bigeye shiner *Notropis boops*  
 Ironcolor shiner *Notropis chalybaeus*  
 Blackchin shiner *Notropis heterodon*  
 Blacknose shiner *Notropis heterolepis*  
 Ozark minnow *Notropis nubilus*  
 Rosyface shiner *Notropis rubellus*  
 Weed shiner *Notropis texanus*  
 Mimic shiner *Notropis volucellus*  
 Pugnose minnow *Opsopoeodus emiliae*  
 Spottin shiner *Cyprinella spiloptera*  
 Blacktail shiner *Cyprinella venusta*  
 Steelcolor shiner *Cyprinella whipplei*  
 Southern redbelly dace *Phoxinus erythrogaster*  
 Bullhead minnow *Pimephales vigilax*  
 Blacknose dace *Rhinichthys atratulus*

**CATOSTOMIDAE**

Highfin Carpsucker *Carpiodes velifer*  
 Blue sucker *Cycleptus elongatus*  
 Lake chubsucker *Erimyzon sucetta*  
 Northern hog sucker *Hypentilium nigricans*  
 Silver redhorse *Moxostoma anisurum*  
 River redhorse *Moxostoma carinatum*  
 Black redhorse *Moxostoma duquesnei*

**ICTALURIDAE**

Mountain madtom *Noturus eleutherus*  
 Slender madtom *Noturus exilis*  
 Stonecat *Noturus flavus*  
 Brindled madtom *Noturus miurus*  
 Northern madtom *Noturus stigmosus*

**CENTRARCHIDAE**

Rock bass *Ambloplites rupestris*  
 Longear sunfish *Lepomis megalotis*  
 Smallmouth bass *Micropterus dolomieu*

**PERCIDAE**

Western sand darter *Ammocrypta clara*  
 Eastern sand darter *Ammocrypta pellucida*  
 Greenside darter *Etheostoma bienniodes*  
 Rainbow darter *Etheostoma caeruleum*  
 Bluebreast darter *Etheostoma camurum*  
 Iowa darter *Etheostoma exile*  
 Fantail darter *Etheostoma flabellare*  
 Harlequin darter *Etheostoma histrio*  
 Stripetail darter *Etheostoma kennicotti*  
 Least darter *Etheostoma microperca*  
 Orangethroat darter *Etheostoma spectabile*  
 Spottail darter *Etheostoma squamiceps*  
 Banded darter *Etheostoma zonale*  
 Slenderhead darter *Percina oxocephala*  
 Dusky darter *Percina sciera*

**COTTIDAE**

Mottled sculpin *Cottus bairdi*  
 Banded sculpin *Cottus caroliniae*



## **Standard Operating Procedure (#99-0034-SOP-05) for the Qualitative Stream Habitat Assessment Procedure**

### **1. Scope & Summary**

This standard operating procedure (SOP) outlines techniques for performing a Qualitative Stream Habitat Assessment Procedure (SHAP) in lotic environments. The results of the SHAP will specifically be used in conjunction with an Index of Biotic Integrity (IBI) survey to legitimize fish sampling stations.

### **2. Reference Documents**

IEPA (1994) *Quality Assurance Project Plan - Integrated Water Monitoring Program Document*. Section E; Subsection 5. Bureau of Water - Division of Laboratories. Springfield, IL.

### **3. Significance and Use**

SHAPs are used as a qualitative approach to evaluate lotic habitat quality using features considered important to biotic integrity. SHAPs facilitate an assessment of stream quality predicted on 15 metrics associated with bottom substrate type, channel morphology, hydrology, and riparian features. Each metric is subjectively assessed and assigned to one of four habitat quality categories. The total possible score for each metric can range from a high of 20 for bottom substrate, to eight for channel sinuosity and top-of-bank land use. The total score of the stream reach assessed forms the basis of the overall habitat quality rating for the stream and can be used as a tool for biocriteria assessments when evaluating the relationship of habitat quality to biotic integrity.

### **4. Potential Interferences**

- 4.1. Inclement weather (i.e., heavy rain, lightning, strong winds) may potentially interfere with assessment activities. SHAPs should only be conducted in fair weather so that the investigator is not exposed to dangerous conditions and so that SHAP scores are not influenced by temporary weather changes.
- 4.2. Rapid flow conditions may potentially interfere with assessment activities. SHAPs should be conducted in preferably low flow conditions so that the investigator can properly assess the habitat without the fear of losing footing while wading.
- 4.3. High water in the area of the assessment will interfere with SHAPs and will not be representative of true site-specific conditions. High water will not allow the investigator to make proper judgements about site-specific conditions such as depth of pools, presence of riffles, snags, undercut bank or sandbars.

### **5. Materials**

- SHAP field data sheets on "Rite-In-The-Rain" paper;
- SHAP protocols;
- "Rite-In-The-Rain" Notebooks;

- Waders;
- Polarized sunglasses;
- Measuring tape;
- Pencils/waterproof pens;
- Depth finder;
- Sunscreen;
- Insect repellent;
- Stakes;
- Hammer;
- Flagging;
- PFD;
- Clipboard;
- Digital camera/disks or camera/film;
- First Aid Kit.

## **6. Hazards & Precautions**

- 6.1. The investigator should avoid performing SHAPs when inclement weather conditions are present such as thunder and lightning, strong winds, heavy rain and associated high water. Dangerous weather conditions increase the risk of electrocution, falling limbs and drowning.
- 6.2. The investigator should avoid performing SHAPs when rapid flow conditions are present. SHAPs are conducted while wading and rapid flow conditions could potentially cause the investigator to lose footing and be swept away by the current resulting in possible drowning.

## **7. Procedure**

Qualitative SHAPs involve five basic steps: (1) Select stream reach; (2) Conduct a reconnaissance or wade the reach to be evaluated; (3) Make preliminary notes on stream width and depth and on pool depth; (4) Wade the reach and score habitat metrics on SHAP field form; (5) Determine final reach score.

- 7.1. Reach selection (1) – The first step in assessing stream habitat quality with the qualitative SHAP approach requires the investigator(s) to select the stream reach to be evaluated. Normally, the segment selected will depend on the objectives and type of survey being conducted. For the purposes of this project, the stream segment assessed with SHAP will be identical to the length of the reach sampled for fish during the IBI. An IBI sampling reach (both reference and "study") will preferably contain two riffles, two runs, and two pools and will have a length of 100-200 yards. Once a reference reach has been chosen and found to be representative of the study area, a "study" sampling reach is chosen which is also representative of the study area. For stations where fish are collected over an extremely long section of stream (i.e., 100-200 yards), it will normally be desirable to select a representative section within this reach to conduct the SHAP.
- 7.2. Reach Reconnaissance (2) and Preliminary Documentation (3) – The second and third steps in utilizing SHAPs are to conduct a preliminary reconnaissance of the stream segment to be evaluated with both the reference and study reaches. The purpose of this initial "walk-through" is

to acquire a general familiarity with the size and depth of the stream, substrate characteristics, and location of pools and significant instream cover. The investigator should take notes on mean stream width and pool depth as necessary.

- 7.3. Score Each Reach Using SHAPs (4)/(5) - Habitat parameter ratings are divided into four habitat quality categories based on their assumed importance to biotic integrity (excellent, good, fair and poor). Metric scores are correspondingly, divided into four groups within each category, with each metric having a possible range of up to four points within that category (see SHAP Field Data Sheet in Appendix A of the Sampling and Analysis Plan). There are a total of 15 different metrics assessed to aid in determining the quality of the stream when using SHAPs. The metrics are as follows:

- Bottom substrate;
- Deposition;
- Substrate stability;
- Instream cover;
- Pool substrate characterization;
- Pool quality;
- Pool variability;
- Canopy cover;
- Bank vegetative protection/stability;
- Top of bank land use;
- Flow-related refugia;
- Channel alternation;
- Channel sinuosity;
- Width/Depth ratio; and
- Hydrologic diversity

The first task in assessing habitat quality of a stream reach requires rating the reach based on one of the four categories (excellent, good, fair, or poor) on the field form which best reflects the observed habitat quality for that metric. After choosing a category, specific scores are assigned according to the following basic rules:

- 7.3.1. If the habitat in the present reach matches one category fairly well, but also matches some of the criteria of an adjacent category, a score at the end of the range toward the second category should be chosen (e.g., if the category with score range 11-15 matches best, but the category with score range 6-10 matches to some degree, a score of 11 should be chosen).
- 7.3.2. Other numbers (e.g., 7 and 9 in the range 6-10), if available, can be utilized for discriminating among "shades of gray".
- 7.3.3. Two habitat quality metrics (i.e., width/depth ratio and channel sinuosity) are designated as office assessments, and thus should be calculated with measured information if available.

7.3.4. Initially, it is recommended that two staff biologists rate each habitat reach. These assessments should be done independently, and then differences resolved amicably with each metric receiving one score, which is recorded on the final version of the habitat assessment form. At which time staff develop an acceptable degree of precision in rating habitat metrics, scoring may be accomplished by one person, although a cooperative effort is desirable.

- 7.4. Determining a Final Reach Score and Reach Comparison – Once each metric has been scored, all metrics should be added together to yield a total score (see SHAP Field Data Sheet Appendix A of the SAP). The total score from the reference station will then be compared to the total score from the study station. To find the percent similarity between the two stations, divide the smaller total score by the larger total score and then multiply by 100 (i.e., if the total score of the study station was 102 and the total score of the reference station was 155, the following order of operations should occur:  $102/155 = 0.658 \times 100 = 65.8\%$ )

Table 1 will guide the investigator in determining the percent similarity between the reference station and the study station. In the example referenced in Section 7.4, the similarity between the reference and study stations would be considered *Fair (Moderately Different)*.

**Table 1. Stream Habitat Percent Similarity Categories for Site Comparability Assessments (from Michigan DNR 1991).**

Habitat Quality Category	Percent Similarity
Excellent (Very Similar to Reference)	> 90%
Good (Slightly Different)	75-89%
Fair (Moderately Different)	60-74%
Poor (Substantially Different)	≤ 59%

## 8. Applicable Forms

SHAP Field Data Sheet

Reach Pool Quality Rating Sheet

Photograph Log

**QUALITATIVE STREAM HABITAT ASSESSMENT PROCEDURE FIELD DATA SHEET - (PAGE 1 of 2)**

STREAM NAME:		LOCATION:		FORM COMPLETED BY:	
STATION #:		RIVERMILE:		STREAM CLASS:	
LAT:		LONG:		REACH LENGTH:	
MANAGING COMPANY/AGENCY:		DATE:		REASON FOR SURVEY:	
		TIME: _____ AM PM			

Habitat Parameter	Condition Category			
	Excellent	Good	Fair	Poor
<b>1. Bottom Substrate</b>	Greater than 50% gravel, cobble, or boulders.	30-50% consolidated gravel, cobble, or boulders.	10-30% gravel (largely unconsolidated), cobble, or boulders.	Less than 10% gravel, cobble, or boulders; predominantly sand or silt.
<b>SCORE:</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
<b>2. Deposition</b>	Less than 5% affected; minor accumulation of coarse particles at channel bars, point bars, snags, or submerged vegetation.	5-30% affected; moderate accumulation of sand/gravel at channel/point bars snags, or submerged vegetation.	5-30% affected; major deposition of sand at channel/point bars, snags, or submerged vegetation; pools shallow from heavy deposition.	Mud, silt and/or sand in braided or nonbraided channels; pools almost absent due to deposition.
<b>SCORE:</b>	12 11 10 9 8	7 6 5 4 3	2 1	
<b>3. Substrate Stability</b>	Abundance of boulders or cobble; periphyton/aquatic vegetation often abundant.	Presence of some boulders or cobble with some periphyton.	Few boulders and cobble; small shifting particles common; periphyton rare; OR predominantly claypan or bedrock.	Stable substrate types absent; small gravel, sand and silt abundant; periphyton usually absent or present only during low flow.
<b>SCORE:</b>	16 15 14 13	12 11 10 9	8 7 6 5 4	3 2 1
<b>4. Instream Cover (for pan fish juveniles or adults)</b>	Abundant submerged logs, undercut banks, or other stable habitat (>12% of stream).	Adequate habitat (6-12% of stream).	Habitat availability less than desirable (2-6% of stream).	Lack of habitat is obvious (<2% of stream).
<b>SCORE:</b>	12 11 10 9 8	7 6 5 4 3	2 1	
<b>5. Pool Substrate Characterization</b>	Mixture of coarse substrate materials with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud/clay or sandy bottom; little or no root mat, no submerged vegetation; older channelization.	Hard-pan clay or bedrock; no root mat or vegetation; OR regularly maintained channel with shifting silt/sand; OR pools absent.
<b>SCORE:</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
<b>6. Pool Quality</b>	(SEE FLOW CHART)			
<b>SCORE:</b>				
<b>7. Pool Variability</b>	Approximately equal mix of deep/shallow/large/ small pools present.	Majority of pools large and deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small and shallow or pools absent.
<b>SCORE:</b>	16 15 14 13	12 11 10 9	8 7 6 5	4 3 2 1
<b>8. Canopy Cover (Shading)</b>	A mixture of conditions where some areas of water surface fully exposed to sunlight, and others receiving various degrees of filtered light.	Covered by sparse canopy; entire water surface receiving filtered light.	Water surface completely shaded (100%) OR nearly full sunlight reaching water surface (10-20%); shading limited to <3 hours per day.	Lack of canopy, full sunlight reaching water surface (0-10%).
<b>SCORE:</b>	12 11 10 9	8 7 6 5	4 3 2 1	

**QUALITATIVE STREAM HABITAT ASSESSMENT PROCEDURE FIELD DATA SHEET - (PAGE 2 of 2)**

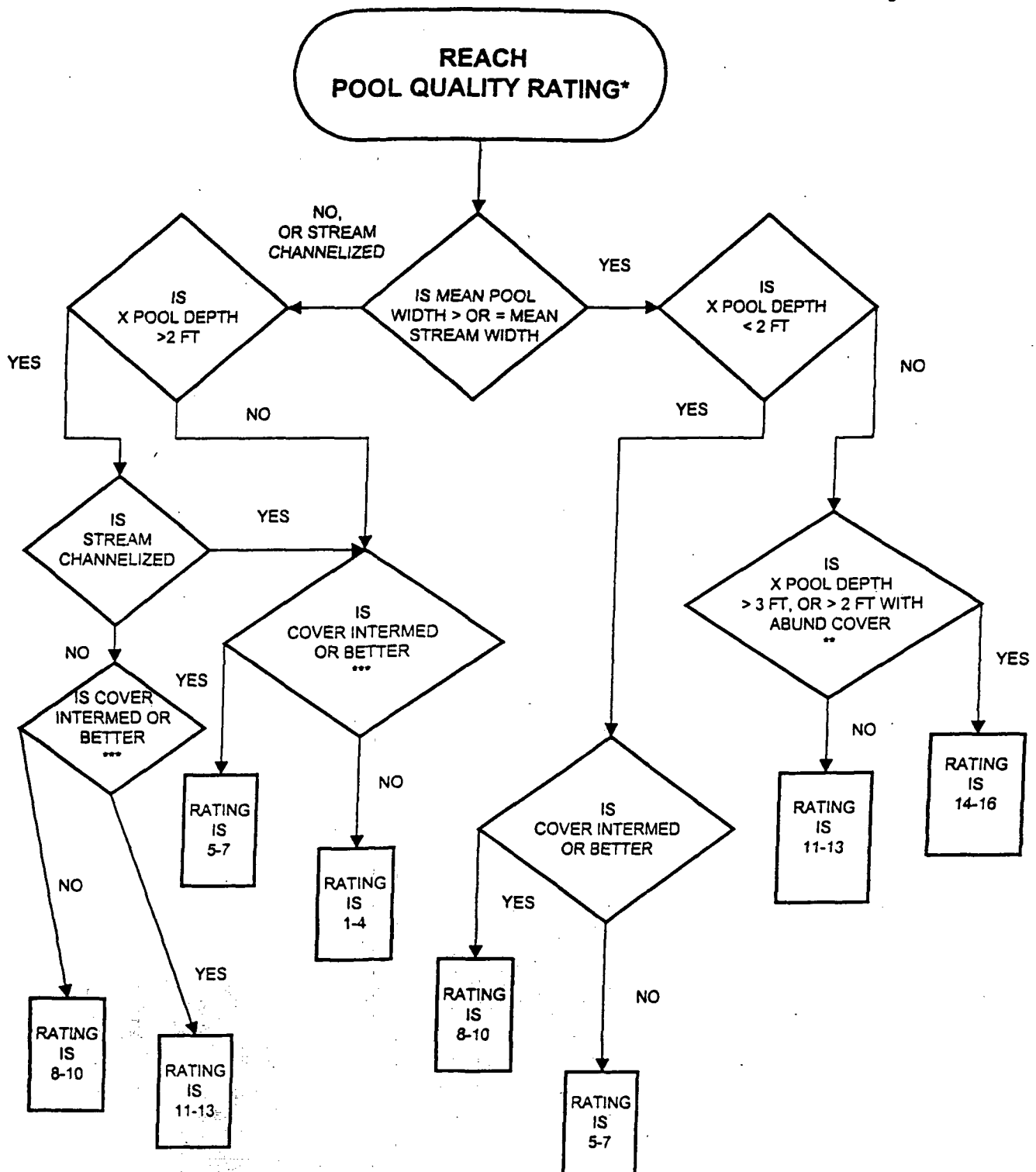
Habitat Parameter	Condition Category			
	Excellent	Good	Fair	Poor
<b>9. Bank Vegetative Protection/Stability (water's edge to top of bank)</b>	Over 90% of the streambank surfaces covered by vegetation or bare rock.	70-90% of the streambank surfaces covered by vegetation or bare rock.	50-70% of the streambank surfaces covered by vegetation or bare rock; OR older channelization.	Less than 50% of the streambank surfaces covered by vegetation or bare rock; OR new or regularly maintained channelization.
<b>SCORE:</b>	16 15 14 13	12 11 10 9	8 7 6 5	4 3 2 1
<b>10. Top of Bank Land Use (top of bank to 30 yds inland)</b>	Well vegetated; or $\geq 90\%$ in *undisturbed land uses.	Generally undisturbed (70-90%).	Moderately undisturbed (40-70%).	Little of immediate watershed undisturbed (<40%).
<b>SCORE:</b>	8 7 6 5	4 3 2 1	8 7 6 5	4 3 2 1
	*Undisturbed = bare rock, woodland, shrubs, wetland	*Disturbed = crop, pasture, barnyard, commercial, residential, levee		
<b>11. Flow-related Refugia</b>	Readily available refugia at all flow regimes.	Abundant stable cover for fish present between water's edge and top of bank; moderate pool depth at low flows.	Sparse cover for fish present between water's edge and top of bank; OR pools nearly absent at low flow.	Lack of refugia at most stream stages.
<b>SCORE:</b>	12 11 10 9	8 7 6 5	4 3 2 1	8 7 6 5
<b>12. Channel Alteration</b>	Little or no enlargement of islands or point bars, and/or no channelization.	Some natural channel modification, or recovered old channelization.	Older channelization in various degrees of recovery.	Extensive recent or regularly maintained channelization.
<b>SCORE:</b>	8 7 6 5	4 3 2 1	8 7 6 5	4 3 2 1
<b>13. Channel Sinuosity (** office)</b>	Instream channel length 3 to 4 time straight line distance.	Instream channel length 2 to 3 times straight line distance.	Instream channel length 1 to 2 times straight line distance.	Channel straight; channelized waterway.
<b>SCORE:</b>	12 11 10 9	8 7 6 5	4 3 2 1	8 7 6 5
<b>14. Width/Depth Ratio (mean width divided by mean thalweg depth) (** office)</b>	Stream very deep and narrow; width/depth $\leq 7$ .	Stream moderately deep and narrow; width/depth 8-15.	Stream moderately shallow with some deep areas; width/depth 15-25.	Stream relatively wide and shallow; width/depth > 25.
<b>SCORE:</b>	16 15 14 13	12 11 10 9	8 7 6 5	4 3 2 1
<b>15. Hydrologic Diversity (pools, riffles, runs, bends)</b>	Variety of habitats; deep riffles and pools; diverse velocities readily apparent.	Adequate depth in pools and riffles; bends provide habitat; good velocity diversity.	Occasional riffle or bend; bottom contours provide some habitat; fair velocity diversity.	Essentially a straight stream with poor habitat; uniform velocity.
<b>SCORE:</b>	12 11 10 9	8 7 6 5	4 3 2 1	8 7 6 5

**TOTAL SCORE** \_\_\_\_\_

**\*\*Indicates that assessment based on measured habitat information is recommended.**

**Representativeness of sampled reach to entire stream reach:**    **Excellent**    **Good**    **Fair**    **Poor**    **(circle one)**

**Comments:** \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_



\*\* Abundant cover = excellent in-pool cover plus cover on most of pool perimeter  
 \*\*\* Intermediate cover = moderate in-pool cover plus cover on 1/2 pool perimeter

Flowchart for assessing stream pool quality (modified from Platts et al. 1983).  
 (Taken from IEPA, 1994)



## **Standard Operating Procedure (#99-0034-SOP-06) for the Physical Characterization/Water Quality and Habitat Assessment**

### **1. Scope & Summary**

This standard operating procedure (SOP) outlines techniques for performing a Physical Characterization/Water Quality and Habitat Assessment associated with fish sampling and Index of Biotic Integrity protocols. An evaluation of habitat quality is critical to any assessment of ecological integrity and should be performed at each site at the time of the biological sampling.

### **2. Reference Documents**

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

### **3. Significance and Use**

The presence of an altered habitat structure is considered one of the major stressors of aquatic systems. The presence of a degraded habitat can sometimes obscure investigations on the effects of toxicity and/or pollution. The assessments performed by many water resource agencies include a general description of the site, a physical characterization and water quality assessment, and a visual assessment of instream and riparian habitat quality. Together these data provide an integrated picture of several of the factors influencing the biological condition of a stream system.

The combination of physical characterization and water quality will provide insight as to the ability of the stream to support a healthy aquatic community, and to the presence of chemical and non-chemical stressors to the stream ecosystem.

The habitat quality evaluation can be accomplished by characterizing selected physicochemical parameters in conjunction with a systematic assessment of physical structure. Through this approach, key features can be rated or scored to provide a useful assessment of habitat quality.

### **4. Potential Interferences**

- 4.1. Inclement weather (i.e., heavy rain, lightning, strong winds) may potentially interfere with assessment activities. Physical characterization/water quality and habitat assessment activities should only be conducted in fair weather so that the investigator is not exposed to dangerous conditions and so that assessment results are not influenced by temporary weather changes.
- 4.2. Rapid flow conditions may potentially interfere with assessment activities. Physical characterization/water quality and habitat assessment activities should be conducted in preferably low flow conditions so that the investigator can properly assess the habitat and collect measurements without the fear of losing footing while wading.

- 4.3. High water in the area of the assessment will interfere with assessment procedures and will not be representative of true site-specific conditions. High water will not allow the investigator to make proper judgements about site-specific conditions such as substrate composition, pool descriptions, channel and bank descriptions and width/length measurements.

## 5. Materials

- Physical Characterization/Water Quality and Habitat Assessment field data sheets on "Rite-In-The-Rain" paper;
- Physical Characterization/Water Quality and Habitat Assessment Protocols;
- "Rite-In-The-Rain" Notebooks;
- Waders;
- Polarized sunglasses;
- Measuring tape;
- Flow meter;
- *In situ* water quality meters and user manuals;
- Pencils/waterproof pens;
- Depth finder;
- Sunscreen;
- Insect repellent;
- Stakes;
- Hammer;
- Flagging;
- PFD;
- Clipboard;
- Digital camera/disks or camera/film;
- First Aid Kit

## 6. Hazards & Precautions

- 6.1. The investigator should avoid performing physical characterization/water quality and habitat assessment activities when inclement weather conditions are present such as thunder and lightning, strong winds, heavy rain and associated high water. Dangerous weather conditions increase the risk of electrocution, falling limbs and drowning.
- 6.2. The investigator should avoid performing physical characterization/water quality and habitat assessment activities when rapid flow conditions are present. These activities are conducted while wading and rapid flow conditions could potentially cause the investigator to lose footing and be swept away by the current resulting in possible drowning.

## 7. Procedure

Physical characterization includes documentation of general land use, description of the stream origin and type, summary of the riparian vegetation features, and measurements of instream parameters such as width, depth, flow, and substrate. The water quality discussed in these protocols are *in situ* measurements of standard parameters that can be taken with a water quality instrument. Finally, for streams, an encompassing approach to assessing structure of the habitat includes an evaluation of the variety and

quality of the substrate, channel morphology, bank structure, and riparian vegetation. Habitat parameters pertinent to the assessment of habitat quality include those that characterize the stream "micro scale" habitat (e.g., estimation of embeddedness), the "macro scale" features (e.g., channel morphology), and the riparian and bank structure features that are most often influential in affecting the other parameters.

- 7.1. Select the reach (reference or study) that will be assessed first. Preferably, the downstream reach will be assessed prior to the upstream reach. If the downstream reach is assessed first, then no measurements could then be affected by assessment activities that may have taken place at the upstream reach. All measurements collected during the physical characterization/water quality and habitat assessment should be collected while wading. Wading allows for the collection of reach-specific data required by assessment protocols.
- 7.2. All water quality readings should be collected first. The least amount of disturbance in the assessment area is desired so that no water quality readings will be affected by wading.
  - 7.2.1. Collect temperature, specific conductance, dissolved oxygen, pH and turbidity measurements in the area of sampling and record the results on the Physical Characterization/Water Quality Field Data Sheet. All measurements should be collected with the investigator standing downstream of the water quality instrument. Record the type of water quality instrument used to collect the readings.
- 7.3. Record all physical characterization criteria of the reach as required by the Physical Characterization/Water Quality Field Data Sheet.
- 7.4. Record all habitat assessment criteria of the reach as required by the Habitat Assessment Field Data Sheet-Low Gradient Streams (the area of study is on the tailwaters of the Embarras River. Hence, "Low Gradient Streams" data sheet).

## **8. Applicable Forms**

Physical Characterization/Water Quality Field Data Sheet

Habitat Assessment Field Data Sheet-Low Gradient Streams

Photograph Log

**PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (PAGE 1 of 2)**

STREAM NAME:		LOCATION:	
STATION #:	RIVERMILE:	STREAM CLASS:	
LAT:	LONG:	RIVER BASIN:	
MANAGING COMPANY/AGENCY:		INVESTIGATORS:	
FORM COMPLETED BY:		DATE: _____ TIME: _____ AM PM	REASON FOR SURVEY:
WEATHER CONDITIONS	Current Conditions:		Past 24 hours:
	<input type="checkbox"/> storm (heavy rain)		<input type="checkbox"/>
	<input type="checkbox"/> rain (steady rain)		<input type="checkbox"/>
	<input type="checkbox"/> showers (intermittent)		<input type="checkbox"/>
	____% <input type="checkbox"/> % cloud cover		<input type="checkbox"/> ____%
	<input type="checkbox"/> clear/sunny		<input type="checkbox"/>
Has there been an heavy rain in the last 7 days? <input type="checkbox"/> Yes <input type="checkbox"/> No		Air Temperature: _____ °C/°F	
Other:			
SITE LOCATION/MAP	Draw a map of the site and indicate the areas sampled (or attach a photograph)		
STREAM CHARACTERIZATION	Stream Subsystem:		Stream Type:
	<input type="checkbox"/> Perennial <input type="checkbox"/> Intermittent <input type="checkbox"/> Tidal		<input type="checkbox"/> Coldwater <input type="checkbox"/> Warmwater
Stream Origin:		Catchment Area:	
<input type="checkbox"/> Glacial <input type="checkbox"/> Spring-fed			
<input type="checkbox"/> Non-glacial montane <input type="checkbox"/> Mixture of origins			
<input type="checkbox"/> Swamp or bog <input type="checkbox"/> Other:			
		km <sup>2</sup>	

**PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (PAGE 2 of 2)**

<b>WATERSHED FEATURES</b>	<b>Predominant Surrounding Landuse:</b> <input type="checkbox"/> Forest <input type="checkbox"/> Commercial <input type="checkbox"/> Field/Pasture <input type="checkbox"/> Industrial <input type="checkbox"/> Agricultural <input type="checkbox"/> Residential <input type="checkbox"/> Other: _____	<b>Local Watershed NPS Pollution:</b> <input type="checkbox"/> No evidence <input type="checkbox"/> Some potential sources <input type="checkbox"/> Obvious sources <b>Local Watershed Erosion:</b> <input type="checkbox"/> None <input type="checkbox"/> Moderate <input type="checkbox"/> Heavy																																														
<b>RIPARIAN VEGETATION (18 meter buffer)</b>	<b>Indicate the dominant type and record the dominant species present:</b> <input type="checkbox"/> Trees <input type="checkbox"/> Shrubs <input type="checkbox"/> Grasses <input type="checkbox"/> Herbaceous <b>Dominant species present:</b> _____																																															
<b>INSTREAM FEATURES</b>	Estimated Reach Length: _____ m Estimated Stream Width: _____ m Sampling Reach Area: _____ m <sup>2</sup> Area in km <sup>2</sup> (m <sup>2</sup> x1000): _____ km <sup>2</sup> Estimated Stream Depth: _____ m Surface Velocity: (at thalweg) _____ m/sec	<b>Canopy Cover:</b> <input type="checkbox"/> Partly open <input type="checkbox"/> Partly shaded <input type="checkbox"/> Shaded <b>High Water Mark:</b> _____ m <b>Proportion of Reach Represented by Stream Morphology Types:</b> <input type="checkbox"/> Riffle _____ % <input type="checkbox"/> Run _____ % <input type="checkbox"/> Pool _____ % <b>Channelized:</b> <input type="checkbox"/> Yes <input type="checkbox"/> No <b>Dam Present:</b> <input type="checkbox"/> Yes <input type="checkbox"/> No																																														
<b>LARGE WOODY DEBRIS (LWD)</b>	LWD: _____ m <sup>2</sup> Density of LWD: _____ m <sup>2</sup> /km <sup>2</sup> (LWD/reach area)																																															
<b>AQUATIC VEGETATION</b>	<b>Indicate the dominant type and record the dominant species present:</b> <input type="checkbox"/> Rooted emergent <input type="checkbox"/> Rooted submergent <input type="checkbox"/> Rooted floating <input type="checkbox"/> Free floating <input type="checkbox"/> Floating Algae <input type="checkbox"/> Attached Algae <input type="checkbox"/> None present <b>Dominant species present:</b> _____ <b>Portion of reach with aquatic vegetation:</b> _____ % <b>Descriptions:</b> _____																																															
<b>WATER QUALITY</b>	Temperature: _____ °C Specific Conductance: _____ µmhos Dissolved Oxygen: _____ mg/L pH: _____ Turbidity: _____ WQ Instruments Used: _____ _____ _____	<b>Water Odors:</b> <input type="checkbox"/> Normal/None <input type="checkbox"/> Fishy <input type="checkbox"/> Chemical <input type="checkbox"/> Petroleum <input type="checkbox"/> Sewage <input type="checkbox"/> Other: _____ <b>Water Surface Oils:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globbs <input type="checkbox"/> None <input type="checkbox"/> Flecks <input type="checkbox"/> Other: _____ <b>Turbidity (if not measured):</b> <input type="checkbox"/> Clear <input type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other: _____																																														
<b>SEDIMENT/SUBSTRATE</b>	<b>Odors:</b> <input type="checkbox"/> Normal <input type="checkbox"/> Sewage <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Anaerobic <input type="checkbox"/> None <input type="checkbox"/> Other: _____ <b>Oils:</b> <input type="checkbox"/> Absent <input type="checkbox"/> Slight <input type="checkbox"/> Moderate <input type="checkbox"/> Profuse	<b>Deposits:</b> <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Paper fiber <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells <input type="checkbox"/> Other: _____ <b>Looking at stones which are not deeply embedded, are the undersides black in color?</b> <input type="checkbox"/> Yes <input type="checkbox"/> No																																														
<table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th colspan="3">INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)</th> <th colspan="3">ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)</th> </tr> <tr> <th>Substrate Type</th> <th>Diameter</th> <th>% Composition in Sampling Reach</th> <th>Substrate Type</th> <th>Characteristic</th> <th>% Composition in Sampling Area</th> </tr> </thead> <tbody> <tr> <td>Bedrock</td> <td></td> <td></td> <td rowspan="2">Detritus</td> <td rowspan="2">sticks, wood, coarse plant materials (CPOM)</td> <td></td> </tr> <tr> <td>Boulder</td> <td>&gt; 256 mm (10")</td> <td></td> <td></td> </tr> <tr> <td>Cobble</td> <td>64-256 mm (2.5"-10")</td> <td></td> <td rowspan="2">Muck-Mud</td> <td rowspan="2">black, very fine organic (FPOM)</td> <td></td> </tr> <tr> <td>Gravel</td> <td>2-64 mm (0.1"-2.5")</td> <td></td> <td></td> </tr> <tr> <td>Sand</td> <td>0.06-2 mm (gritty)</td> <td></td> <td rowspan="3">Marl</td> <td rowspan="3">grey, shell fragments</td> <td></td> </tr> <tr> <td>Silt</td> <td>0.004-0.06 mm</td> <td></td> <td></td> </tr> <tr> <td>Clay</td> <td>&lt; 0.004 mm (slick)</td> <td></td> <td></td> </tr> </tbody> </table>			INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)			Substrate Type	Diameter	% Composition in Sampling Reach	Substrate Type	Characteristic	% Composition in Sampling Area	Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)		Boulder	> 256 mm (10")			Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)		Gravel	2-64 mm (0.1"-2.5")			Sand	0.06-2 mm (gritty)		Marl	grey, shell fragments		Silt	0.004-0.06 mm			Clay	< 0.004 mm (slick)		
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**HABITAT ASSESSMENT FIELD DATA SHEET - LOW GRADIENT STREAMS (PAGE 1 of 2)**

STREAM NAME:		LOCATION:		
STATION #:	RIVERMILE:	STREAM CLASS:		
LAT:	LONG:	RIVER BASIN:		
MANAGING COMPANY/AGENCY:		INVESTIGATORS:		
FORM COMPLETED BY:		DATE: _____ TIME: _____ AM PM	REASON FOR SURVEY:	

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
<b>1. Epifaunal Substrate/Available Cover</b>	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE:	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
<b>2. Pool Substrate Characterization</b>	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE:	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
<b>3. Pool Variability</b>	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep, very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE:	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
<b>4. Sediment Deposition</b>	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE:	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
<b>5. Channel Flow Status</b>	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE:	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

**HABITAT ASSESSMENT FIELD DATA SHEET - LOW GRADIENT STREAMS (PAGE 2 of 2)**

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
<b>6. Channel Alteration</b>	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr.) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
<b>SCORE:</b>	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	5 4 3 2 1 0
<b>7. Channel Sinuosity</b>	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note: channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
<b>SCORE:</b>	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	5 4 3 2 1 0
<b>8. Bank Stability (score each bank)</b>	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequently, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
<b>SCORE: (LB)</b>	Left Bank 10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0
<b>SCORE: (RB)</b>	Right Bank 10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0
<b>9. Vegetative Protection (score each bank)</b>  <b>Note: determine left or right side by facing downstream.</b>	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is no well-represented; disruption evident but no affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
<b>SCORE: (LB)</b>	Left Bank 10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0
<b>SCORE: (RB)</b>	Right Bank 10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0
<b>10. Riparian Vegetative Zone Width (score each bank riparian zone)</b>	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
<b>SCORE: (LB)</b>	Left Bank 10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0
<b>SCORE: (RB)</b>	Right Bank 10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0	10 9 8 7 6 5 4 3 2 1 0

**Total Score** \_\_\_\_\_



## **Standard Operating Procedure (#99-0034-SOP-07) for the Quantitative Floristic Community Survey**

### **1. Scope & Summary**

This standard operating procedure (SOP) outlines techniques for performing a Quantitative Floristic Community Survey in terrestrial and wet environments. This SOP is not intended to be utilized in environments that have standing water greater than 0.5 meters in depth.

### **2. Reference Documents**

Brower, J.E., J.H. Zar, and C.N. von Ende. 1998. Field and laboratory methods for general ecology. 4th Edition, McGraw-Hill Companies, Inc., New York.

Greig-Smith, P. 1982. Quantitative plant ecology. 3rd Edition Studies in Ecology, Volume 9, Blackwell Scientific, London.

Kent, M. and P. Coker. 1992. Vegetation description and analysis - a practical approach. Belhaven Press, London.

Ludwig, J.A. and J.F. Reynolds. 1988. Statistical ecology - a primer on methods and computing. John Wiley & Sons, New York.

### **3. Significance and Use**

Ecological indices of terrestrial and wetland habitats are typically based on floristic studies. Estimates of floral richness are useful for determining the distribution of plants within a community and are often used to monitor changes in plant communities over temporal and spatial scales. Estimates of floral density are necessary for determining species abundance. Ultimately, the use of various floristic indices will aid in determining the baseline condition of the floral community within the various habitat types within the boundaries of the former Indian Refinery and within the habitats that surround the refinery.

### **4. Potential Interferences**

- 4.1. When surveying a specific habitat type, care should be taken to avoid cross-habitat evaluations. For example, sampling locations should not cross from a successional floodplain forest to a mature floodplain forest as the floristic assemblage will be different from one natural community to another.
- 4.2. Depending upon the type of index used in the field to survey flora, sample plots should remain a minimum distance from each other as to achieve unique sample locations.
- 4.3. An expert in plant taxonomy and plant identification must be utilized in the field during any type of floristic survey. When errors are made in plant identification, interpretations of the data will be invalid and no legitimate conclusions as to the floristic community can be made.

- 4.4. Floristic community surveys should be conducted in the spring and summer seasons. Identification of plants is much easier when flowering parts are visible. Some plants can only be identified when certain morphological characteristics are visible in the spring and summer months.

## **5. Materials**

- Quantitative Floristic Survey-Random Number Table;
- Quantitative Floristic Survey-Field Data Sheet (Woody Vegetation);
- Quantitative Floristic Survey-Field Data Sheet (Ground Layer Vegetation);
- "Rite-In-The-Rain" paper;
- "Rite-In-The-Rain" Notebooks;
- Measuring tapes (100 and 50 meters)
- Compasses
- Transect markers;
- Reflectors;
- Sledge hammer;
- Diameter Breast Height measuring tapes;
- Field guides;
- Tree markers;
- Duct tape;
- Packing tape;
- Hand counters;
- Pencils/waterproof pens;
- Sunscreen;
- Insect repellent;
- Pin flags;
- Flagging;
- Taxonomic keys;
- Clipboard;
- Digital camera/disks or camera/film;
- Tags and plastic bags;
- Hand magnifying lens;
- Maps and aerial photos;
- First Aid Kit.

## **6. Hazards & Precautions**

- 6.1. The investigator should avoid performing floristic community surveys when inclement weather conditions are present such as thunder and lightning, strong winds, and heavy rain. Dangerous weather conditions increase the risk of electrocution, falling tree limbs and slip, trip and falls hazards.

## **7. Definitions**

- 7.1. The following definitions and explanations are given so that the investigator(s) will be familiar with key words and measurements prior to sampling in the field. The terms used in this section will be used frequently in "Section 8 Procedures".

- 7.1.1. Main Transect - The established location of a given habitat where all sampling plots will be generated. For the purposes of this

project, the "Main Transect" is 100-meters in length. See Figure A-1.

- 7.1.2. Perpendicular Transect - A randomly located transect along the Main Transect where Plots will be established. See Figure A-1.
- 7.1.3. Plot - A fixed area established along a transect used to quantitatively survey trees, saplings, seedlings, herbs and cover. For the purposes of this project, a "plot" is 22.56 meters (400 m<sup>2</sup>) in diameter and a total of eight "plots" will be established along the transect in random locations. See Figure A-1.
- 7.1.4. Nested Subplot - A fixed area used to quantitatively survey saplings, seedlings, herbs and cover. For the purposes of this project, the "nested subplot" is located within the center of each plot and is 7.14 meters in diameter (40 m<sup>2</sup>). See Figure A-1.
- 7.1.5. Quadrat - A fixed area used to quantitatively survey herbs and cover. For the purposes of this project, a "quadrat" is 1 m<sup>2</sup> in size, and five "quadrats" are randomly established within each quarter of a plot for a total of 20 per plot. See Figure A-1.
- 7.1.6. Diameter at Breast Height (DBH) - The diameter of a stem at breast height (1.3 meters). DBH is measured using special DBH measuring tapes.
- 7.1.7. Tree - For the purposes of this project, a "tree" is defined as a stem with a DBH of  $\geq 6.6$  cm.
- 7.1.8. Saplings - For the purposes of this project, a "sapling" is defined as a stem with a DBH of  $\geq 2.54$  cm but  $< 6.6$  cm.
- 7.1.9. Seedling - For the purposes of this project, a "seedling" is defined as a stem with a DBH of  $< 2.54$ -cm.

## 8. Field Procedures

- 8.1. Determine where the survey transect is to be located. Once the location has been decided, establish the Main Transect in a north/south or east west trajectory (depending upon the geographic layout of the habitat in question) using a compass. The Main Transect should be established using a 100-meter measuring tape. See Figure A-1.
- 8.2. Once the 100-meter measuring tape has been laid down, establish permanent transect markers at both ends of the Main Transect by hammering the markers into the ground. Transect markers should be sturdy enough to withstand the elements (rain, flooding wind, etc) and should be highly visible. The use of reflectors, marking paint or durable flagging is recommended. Permanent transect markers are used under the assumption that multiple surveys will take place in the future and the same transects will be used to collect floristic data. If future surveys are not

proposed in the study area, then permanent transect markers are not necessary.

- 8.3. Establish four Perpendicular Transect locations along the Main Transect at random intervals. The first Perpendicular Transect location should be no shorter than 11.28 meters from the end of the Main Transect, and the fourth Perpendicular Transect should not be established at greater than 88.72 meters along the Main Transect. Also, Perpendicular Transects should be established so that no Plots overlap. All Plots should be, at a minimum, 1 meter away from each other. See Figure A-1.
- 8.4. Establish Plot locations at random distances perpendicular to the Main Transect. A total of eight Plots should be established. Each Plot should have a unique number and a pin flag or other marker should be placed at the center of the established Plot. See Figure A-1.
- 8.5. Starting at the center of the first Plot, use Plot straps (or equivalent) that are 11.28 meters in length to create the perimeter of the 400 m<sup>2</sup> Plot. Establish the Plot perimeter by placing pin flags (or equivalent) at various locations that are 11.28 meters from the center of the Plot. While establishing Plot perimeters, verify that no Plots overlap with each other, and that all Plots are at least 1 meter away from each other as described in Section 8.3. See Figure A-1.
- 8.6. Starting at the center of the first Plot, use the same Plot straps (or equivalent) as mentioned in Section 8.5 to create the perimeter of the 40 m<sup>2</sup> Nested Subplot. Establish the Nested Subplot perimeter by placing pin flags (or equivalent) at various locations that are 7.14 meters from the center of the Plot. See Figure A-1.
- 8.7. Take DBH measurements of all woody vegetation (trees, saplings and seedlings) within the Plot and Nested Subplot. While taking measurements, complete the "Quantitative Floristic Survey - Field Data Sheet (Woody Vegetation)". On the data sheet, list the species and associated DBH value of all trees (stems with a DBH of  $\geq 6.6$  cm) within the entire Plot. Also, list only the species and number of all saplings (stems with a DBH of  $\geq 2.54$  cm but  $< 6.6$  cm) and seedlings (stems with a DBH of  $< 2.54$  cm) which are observed within the Nested Subplot. Saplings and seedling are not enumerated outside the Nested Subplot and no DBH measurements are collected for these two size groups. As each tree, sapling and seedling is observed within the Plot and Nested Subplot, mark the vegetation somewhere on the stem in a visible location with field chalk. This will allow the investigator to know which stem has been enumerated and which have not. Trees, saplings and seedlings are considered within the Plot or Nested Subplot and should be surveyed if  $\geq \frac{1}{2}$  of the stem is within the perimeter of the Plot or Nested Subplot.
- 8.8. To survey herbs and cover, place a 1-m<sup>2</sup> quadrat at five random locations within each quarter of the Plot. Choose one quarter of the Plot and start at the Plot center. Move along the x-axis of the Plot a random distance (less than 11 meters because the Plot radius is 11.28 meters) and then along the y-axis a random distance (less than 11 meters because the Plot radius is 11.28 meters). Slide the 1-m<sup>2</sup> quadrat under the vegetation at

that location verifying that no vegetation is being covered by the quadrat. See Figure A-1.

- 8.9. Stand directly over the 1-m<sup>2</sup> quadrat. Using the Daubenmire Cover Scale, determine what percentage each species of plant is covering the area of the 1 m<sup>2</sup> quadrat. Complete the "Quantitative Floristic Survey - Field Data Sheet (Ground Layer Vegetation)".
- 8.10. Place a 1-m<sup>2</sup> quadrat in the next sampling location by moving along the x-axis and y-axis random distances from the first quadrat location as described in Section 8.8. Verify that no 1-m<sup>2</sup> quadrat overlaps with another. The use of five 1-m<sup>2</sup> quadrats is recommended. See Figure A-1.
- 8.11. Repeat Sections 8.8, 8.9 and 8.10 until five 1-m<sup>2</sup> quadrats have been surveyed in each quarter of the Plot.
- 8.12. Repeat Sections 8.5 through 8.11 until all 8 Plots have been surveyed. See Figure A-1.

## 9. Office Procedures

- 9.1. Once all field data is collected, data analysis is performed. For the purposes of this project, density will be calculated for trees per 400 m<sup>2</sup> and density will be calculated for saplings/seedlings per 40 m<sup>2</sup>. Basal area will be calculated for trees. Herb species richness will be calculated as number of species per plot or quadrat.

## 10. Calculations

**Frequency of Occurrence** = (number of times species occurred/number of sample units) X 100

**Basal area** = ((DBH<sup>2</sup>) X 0.00007854) X 25, where dbh = diameter at breast height. The conversion factor .00007854 is for circumference to diameter and 25 is to convert to a per hectare unit. This calculation is for a 0.04 or 400m<sup>2</sup> plot.

**Density** = #stems X 25 or If DBH > 0 then Density = 25.

**Relative density** = (density of a species/total density) X 100

**Relative basal area** = (basal area of a species/total basal area) X 100

**Importance Value 200** = relative density + relative basal area

## 11. Applicable Forms

Quantitative Floristic Survey - Random Number Table

Quantitative Floristic Survey - Field Data Sheet (Woody Vegetation)

Quantitative Floristic Survey - Field Data Sheet (Ground Layer Vegetation)

Photograph Log

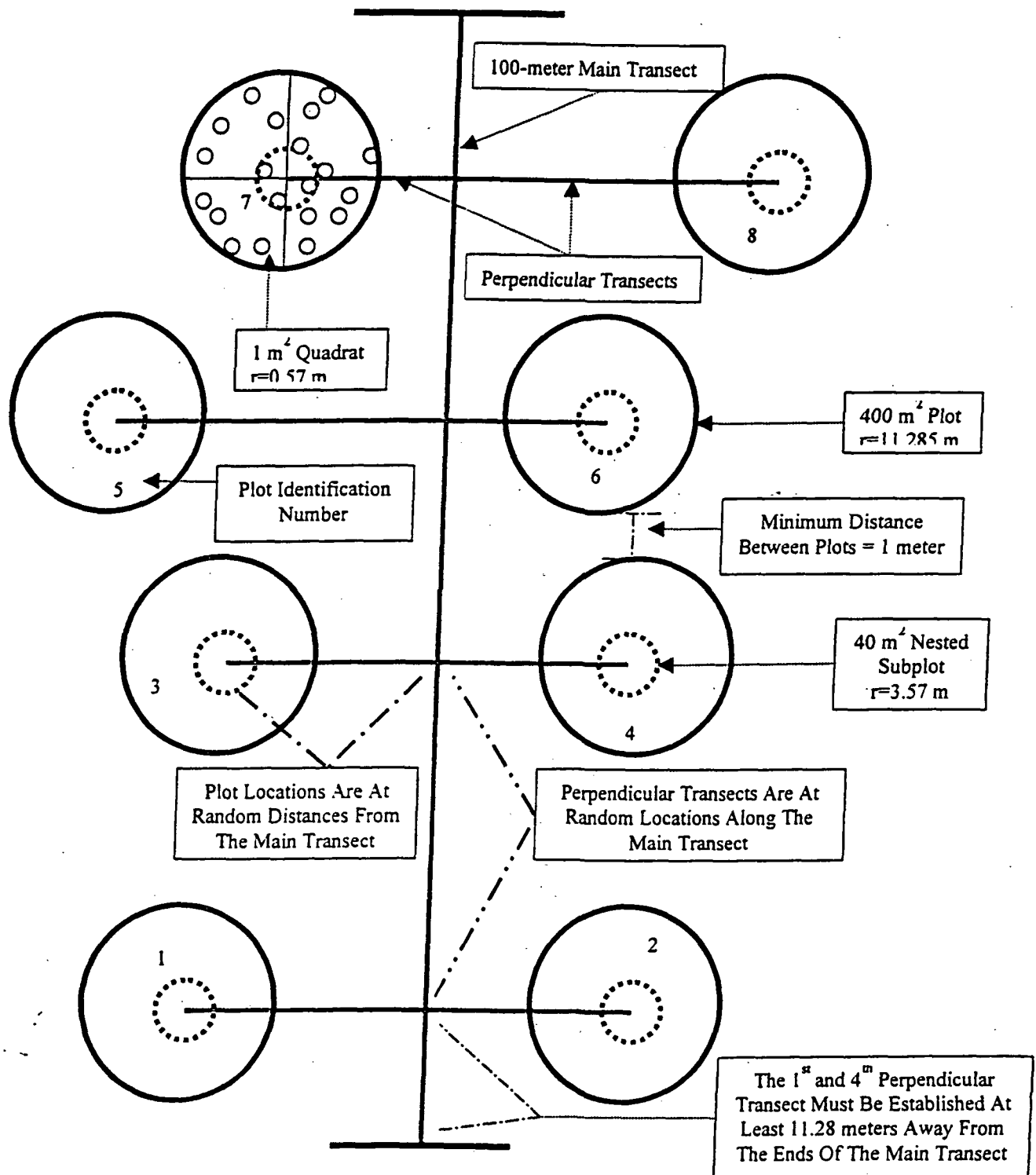


FIGURE A-1 – FLORISTIC SURVEY TRANSECT MODEL

# **QUANTITATIVE FLORISTIC SURVEY RANDOM NUMBER TABLE - SLAG INVESTIGATION**

Random Numbers (in meters) For Plot Transect Placement Along The Main Transect

Placement #	Transect XX	Placement #	Transect XX	Placement #	Transect XX	Placement #	Transect XX
1	12.6	1	12.3	1	12.5	1	12.6
2	38.1	2	36.5	2	37.1	2	38.5
3	64.6	3	62.7	3	61.6	3	63.0
4	88.3	4	87.1	4	88.1	4	86.8
Placement #	Transect XX	Placement #	Transect XX	Placement #	Transect XX	Placement #	Transect XX
1	13.3	1	11.7	1	14.2	1	12.6
2	38.1	2	37.4	2	37.9	2	38.9
3	62.0	3	63.7	3	63.2	3	62.7
4	85.6	4	87.3	4	87.7	4	86.3
Placement #	Transect XX	Placement #	Transect XX	Placement #	Transect XX		
1	12.9	1	13.6	1	12.9		
2	37.1	2	38.7	2	37.6		
3	62.8	3	64.6	3	63.3		
4	87.7	4	88.6	4	88.3		

Random Numbers (in meters) For Plot Placement Away From Main Transect

Plot #	Transect XX	Plot #	Transect XX	Plot #	Transect XX	Plot #	Transect XX
	16.7		37.2		39.2		28.5
	11.9		35.9		19.2		36.3
	31.5		18.0		20.1		29.3
	11.4		13.1		18.6		14.3
	24.4		14.3		22.3		19.0
	31.7		27.3		28.9		37.2
	16.3		13.5		19.6		21.2
	30.8		13.7		16.9		18.9
Plot #	Transect XX	Plot #	Transect XX	Plot #	Transect XX	Plot #	Transect XX
	24.6		35.3		25.8		35.9
	37.2		36.5		34.3		32.2
	25.4		29.7		24.8		16.2
	28.2		30.1		37.2		23.3
	22.9		17.3		38.6		34.6
	12.2		20.5		26.8		14.5
	23.6		28.6		17.2		20.4
	17.4		29.6		23.0		18.1
Plot #	Transect XX	Plot #	Transect XX	Plot #	Transect XX		
	35.9		34.7		27.3		
	32.2		27.8		30.5		
	16.2		25.7		21.7		
	23.3		11.7		33.5		
	34.6		31.9		38.7		
	14.5		12.6		24.2		
	20.4		24.0		35.5		
	18.1		38.4		20.4		

# EXAMPLE RANDOM NUMBERS FOR QUADRAT LOCATIONS-SLAG INVESTIGATION

Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6		Plot 7		Plot 8	
x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)
3.9	3.9	5.0	8.8	6.7	6.8	6.5	3.9	1.1	2.3	5.9	6.4	1.4	2.2	6.5	2.5
3.4	2.2	6.0	4.5	8.7	6.4	5.9	7.1	3.9	7.6	6.6	3.9	4.3	8.7	1.4	6.0
3.0	5.0	8.6	5.2	1.0	8.1	1.6	3.6	1.2	2.2	3.2	5.4	5.3	2.6	2.6	6.4
1.1	9.8	2.3	2.1	6.9	5.4	7.2	2.4	4.2	2.5	3.9	6.9	2.9	2.7	1.4	8.8
6.2	8.9	3.8	2.6	5.0	7.7	2.0	1.9	5.0	6.8	7.4	1.2	4.9	1.7	4.7	3.4
5.1	6.5	1.7	2.3	2.7	2.2	5.8	6.3	6.2	5.2	1.2	5.4	1.5	6.3	3.2	4.1
6.8	1.0	7.4	6.9	7.3	7.3	2.5	7.7	7.8	5.6	1.2	6.7	3.5	6.9	7.8	3.0
1.2	7.7	6.1	2.5	6.8	6.3	6.8	1.7	7.2	3.8	8.3	4.7	8.4	1.7	2.9	4.5
4.6	1.0	2.6	3.4	2.9	7.3	1.6	2.7	1.5	6.4	4.0	6.0	3.3	2.3	4.5	6.4
1.6	6.1	7.9	6.4	5.6	1.8	3.2	3.7	1.1	1.3	7.4	4.5	4.9	4.8	2.3	6.6
1.1	2.9	4.2	1.5	5.3	6.1	2.9	5.4	7.0	1.8	6.0	1.1	5.7	8.6	5.1	4.8
3.6	9.3	2.7	8.1	7.6	7.4	5.5	4.5	3.6	5.3	4.8	4.9	7.4	1.1	3.6	4.3
8.6	1.7	2.2	4.9	2.1	7.2	2.2	6.2	3.7	8.5	7.8	6.6	5.9	2.1	5.3	7.6
5.4	6.7	7.6	2.6	4.9	7.4	3.9	1.4	5.2	1.7	4.6	6.6	1.5	2.4	3.1	5.4
5.8	1.2	4.9	6.4	6.6	7.3	1.1	2.6	7.2	4.7	4.9	3.0	4.6	6.2	6.3	4.6
2.8	6.4	5.5	8.8	8.8	1.1	4.6	6.1	7.8	4.5	6.0	4.6	4.2	1.7	1.7	4.6
6.8	3.6	5.4	4.2	5.9	7.2	8.5	5.4	4.6	3.0	5.5	1.2	4.6	6.7	2.1	7.8
3.4	4.0	6.2	3.4	8.7	2.9	1.4	8.3	6.7	2.3	1.2	7.7	5.0	6.7	3.6	6.4
3.6	2.7	6.9	4.2	1.4	1.3	8.5	1.1	2.5	6.1	2.1	2.7	5.4	5.3	5.2	4.4
7.1	5.9	7.9	6.6	5.9	6.2	7.4	6.1	8.3	2.8	7.4	2.6	5.5	3.5	1.6	7.8
Plot 9		Plot 10		Plot 11		Plot 12		Plot 13		Plot 14		Plot 15		Plot 16	
x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)
4.3	1.8	2.3	3.7	8.6	2.8	7.5	2.8	6.0	7.7	3.1	5.5	2.2	5.6	6.3	3.8
6.1	7.4	3.1	3.3	8.7	6.0	4.4	7.1	7.3	5.6	3.4	2.7	5.4	3.3	7.5	3.4
3.7	4.8	4.0	3.4	5.2	2.0	5.9	8.6	5.9	3.8	9.4	2.0	9.3	4.6	3.3	7.3
7.2	7.1	6.2	1.1	1.5	1.8	3.5	7.8	6.2	3.9	7.9	1.6	3.5	9.0	4.7	8.7
6.7	4.2	5.9	3.5	7.3	4.2	7.7	4.8	8.0	2.2	6.7	6.7	1.3	1.0	4.8	2.9
4.8	5	8.0	6.4	6.8	1.4	8.6	6.1	3.1	4.7	5.2	3.9	1.4	6.1	5.4	1.8
7.9	1.2	5.9	4.0	4.4	1.9	6.7	6.2	8.4	3.8	4.5	7.7	1.7	4.3	1.2	7.8
3.4	5.4	7.1	2.6	5.9	7.6	1.9	4.6	4.1	4.4	8.5	4.6	8.9	4.9	3.6	4.6
7.5	6.3	2.8	3.1	5.8	1.9	4.2	5.0	7.3	3.8	4.9	5.2	5.2	5.9	2.9	4.4
5.3	4.6	3.4	2.5	2.1	4.7	5.4	1.3	5.1	8.1	3.7	8.4	2.9	6.1	3.4	8.9
4.6	7.2	7.7	5.4	6.6	4.6	5.4	3.9	1.8	8.5	6.1	5.7	6.9	2.2	9.1	5.6
3.6	1.5	8.2	5.2	6.0	1.5	6.1	6.7	5.4	3.4	6.5	7.6	4.0	3.8	5.7	3.7
1.6	3.4	8.1	6.5	2.7	2.6	8.0	1.1	4.7	4.4	1.2	3.9	9.0	3.6	3.2	6.5
3.3	2.4	3.7	5.1	8.1	4.7	1.1	4.3	6.3	2.1	5.7	8.3	5.1	2.9	3.1	7.9
1.0	1.0	1.0	7.5	3.6	3.7	2.9	6.4	2.9	3.3	1.2	8.2	5.8	5.1	5.2	6.5
6.1	5.8	5.5	6.9	2.0	2.6	2.3	3.1	5.0	6.4	5.7	8.3	5.2	2.4	4.9	2.8
8.5	6.5	1.1	6.2	2.3	3.5	5.0	2.9	5.2	7.0	1.5	2.5	8.4	4.1	4.3	8.7
5.4	8.1	7.0	5.2	3.0	5.1	6.7	8.4	4.5	1.4	9.2	4.4	3.8	6.8	9.1	4.1
4.0	4.4	7.3	4.3	1.6	6.8	6.8	1.5	4.6	8.1	2.5	5.5	9.1	3.4	8.2	1.3
7.3	4.2	7.3	1.7	2.6	7.3	1.7	3.0	1.1	9.7	8.1	4.1	9.6	1.0	4.4	7.6

# EXAMPLE RANDOM NUMBERS FOR QUADRAT LOCATIONS-SLAG INVESTIGATION

Plot 17		Plot 18		Plot 19		Plot 20		Plot 21		Plot 22		Plot 23		Plot 24	
x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)
7.3	4.7	1.9	3.8	3.2	2.3	1.5	1.4	2.3	2.0	3.3	5.5	7.1	3.9	3.4	8.7
2.9	9.6	9.8	1.5	7.5	4.5	2.8	1.0	8.1	5.7	5.3	8.9	5.5	6.1	1.7	7.1
4.6	9.3	9.9	3.1	1.1	4.7	4.3	9.3	9.3	4.4	5.5	4.0	2.2	5.3	8.5	2.6
4.8	7.9	2.1	5.7	3.5	4.3	4.7	4.2	5.8	5.8	8.9	4.8	2.0	9.6	7.3	3.3
1.7	2.5	7.0	7.1	3.4	9.1	4.2	6.5	9.5	4.4	6.5	1.6	4.1	5.9	3.3	2.6
4.8	3.0	6.1	6.9	3.6	6.8	5.7	8.1	6.5	4.6	9.7	1.9	5.5	8.6	2.4	2.9
8.6	1.8	5.7	3.1	9.6	1.5	6.8	3.2	5.0	4.3	4.5	2.3	4.8	8.9	6.0	5.9
2.5	2.1	1.0	6.2	8.7	6.7	9.8	3.3	4.5	3.7	7.1	1.7	6.1	3.9	1.1	3.6
8.9	2.3	4.3	7.9	4.9	7.3	3.2	4.3	6.8	3.6	6.6	7.8	4.8	2.7	3.1	8.3
9.1	4.8	3.4	2.0	8.4	2.6	7.8	6.1	5.5	3.1	8.8	4.8	6.1	8.3	5.9	4.0
5.4	7.7	6.4	2.2	7.1	6.4	7.5	1.5	8.1	1.5	1.4	5.0	2.5	6.8	5.7	7.4
8.9	6.3	1.1	4.1	5.1	7.8	7.4	2.8	3.1	1.2	8.2	2.3	2.3	7.4	9.4	3.7
9.9	4.4	3.8	5.7	1.3	6.9	7.3	3.0	4.0	2.8	9.8	1.3	9.6	1.4	9.7	4.3
5.5	4.8	9.7	3.1	6.8	5.7	9.3	1.4	9.6	4.2	7.4	2.3	5.6	8.1	7.0	1.6
8.6	1.9	7.0	8.3	8.4	5.2	8.3	2.6	5.3	6.0	4.3	3.2	4.3	9.5	8.5	4.7
2.2	7.7	7.0	1.9	1.0	7.1	2.4	4.2	9.5	4.5	8.3	6.1	9.2	1.9	3.8	9.3
3.8	6.3	4.0	1.0	2.2	2.3	5.8	5.4	1.0	6.6	1.7	5.1	7.3	6.1	1.1	4.8
2.8	4.4	7.4	4.4	9.5	3.4	5.5	1.2	2.7	1.1	5.5	5.4	3.7	3.1	5.2	2.3
3.2	4.8	4.7	9.4	4.4	8.8	1.4	4.1	8.0	5.1	9.3	5.1	7.6	6.1	7.2	7.3
4.3	9.5	7.8	4.1	8.7	2.1	3.3	2.0	5.7	8.5	3.8	5.0	4.2	8.7	6.7	5.1
Plot 25		Plot 26		Plot 27		Plot 28		Plot 29		Plot 30		Plot 31		Plot 32	
x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)
6.4	6.6	5.8	7.1	8.7	3.1	8.8	6.2	5.9	3.5	4.6	7.5	1.1	6.6	9.1	2.7
6.6	3.6	8.2	6.2	8.8	3.8	1.6	3.0	2.5	8.2	1.8	9.6	2.7	8.0	3.3	6.0
1.2	3.2	1.7	7.4	7.9	2.3	3.8	3.6	9.0	1.5	4.2	9.2	5.8	5.3	5.1	3.3
1.1	5.0	7.4	2.5	6.2	5.1	8.1	4.9	1.5	3.5	5.0	1.3	8.3	6.5	6.6	8.0
6.0	2.8	1.1	9.3	5.9	3.5	1.1	2.3	5.6	5.3	7.1	4.5	1.0	9.0	5.4	2.6
4.0	2.2	2.4	8.7	6.0	2.9	2.2	6.3	4.1	6.2	3.9	3.0	7.4	2.3	3.5	7.1
6.4	6.0	1.4	2.7	7.5	4.9	7.7	2.4	7.6	1.8	9.2	1.1	4.2	1.9	3.2	9.8
9.8	1.5	4.7	8.6	1.5	8.6	3.6	1.4	9.5	1.3	9.8	1.7	1.3	8.2	8.0	1.6
3.5	4.3	6.2	2.3	9.6	3.8	2.9	4.4	4.5	9.6	9.6	1.5	9.6	1.3	4.6	4.1
4.0	7.7	9.1	4.4	7.6	3.8	3.2	4.6	2.5	9.3	5.5	7.3	5.0	5.5	3.7	5.4
3.6	7.1	5.6	8.4	7.7	6.2	4.2	7.2	1.4	5.2	9.2	4.1	9.8	3.1	7.6	3.6
1.8	8.7	7.6	2.6	2.7	1.6	7.0	2.1	9.0	1.9	7.6	4.4	6.7	8.6	3.6	9.1
9.9	1.7	8.3	3.8	7.1	2.4	1.1	8.2	7.2	6.3	1.8	8.3	1.9	7.3	6.2	2.5
8.8	5	7.3	1.0	9.1	3.6	7.5	6.4	6.0	2.5	8.2	4.5	9.7	2.4	5.9	7.8
9.9	2.8	6.0	5.9	7.1	6.9	2.1	7.4	5.1	8.3	9.7	2.7	4.4	5.0	9.1	3.2
7.9	3.6	7.7	4.3	8.0	3.6	8.3	6.5	2.8	9.8	4.6	4.2	9.4	1.4	7.6	4.5
7.6	1.1	3.7	6.9	3.5	2.2	7.6	2.9	9.8	1.5	3.4	2.2	3.5	2.4	5.1	4.0
3.1	5.5	7.0	5.3	3.1	9.7	6.7	5.9	8.9	3.0	5.3	4.1	8.8	3.8	1.7	2.6
2.0	3.8	8.2	6.7	9.7	3.2	4.2	5.7	8.8	5.3	1.1	7.4	6.9	2.2	1.4	2.6
3.7	7.8	9.1	5.8	8.2	3.7	3.0	7.7	3.6	3.0	6.3	6.9	4.3	3.5	9.9	4.1

# EXAMPLE RANDOM NUMBERS FOR QUADRAT LOCATIONS-SLAG INVESTIGATION

Plot 33		Plot 34		Plot 35		Plot 36		Plot 37		Plot 38		Plot 39		Plot 40	
x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)
8.9	4.8	5.4	1.4	9.3	2.8	5.6	7.8	7.1	5.3	6.6	4.7	2.3	4.4	8.6	5.5
3.5	2.3	2.6	7.6	3.3	6.3	5.4	3.5	9.1	3.6	1.9	6.1	1.0	7.2	10.0	1.4
7.8	7.2	5.0	1.2	2.2	1.0	5.1	3.8	7.4	3.6	9.7	2.6	8.0	6.4	9.2	3.5
9.1	5.2	7.2	4.7	2.2	1.6	2.5	8.9	4.0	1.3	5.6	2.0	6.7	1.1	5.9	1.4
4.5	3.6	9.1	3.3	4.3	2.7	1.6	3.6	3.4	1.8	7.7	4.0	9.0	2.2	1.6	7.0
1.8	2.7	1.1	6.2	1.9	8.1	3.1	9.7	2.0	9.7	1.8	1.4	9.4	4.6	6.1	5.7
5.4	1.3	6.4	5.3	2.8	5.8	6.2	1	9.4	5.1	9.6	2.0	9.9	1.8	5.4	6.5
2.2	8.1	3.5	3.1	6.2	5.5	1.0	5.1	5.3	6.9	2.3	1.6	7.1	3.5	2.0	4.0
6.6	4.5	5.7	5.6	9.3	5.5	2.2	9.2	6.0	5.2	9.6	2.6	8.0	1.9	6.6	5.2
5.1	9.0	2.7	3.3	2.4	6.0	7.1	4.5	8.8	3.3	2.4	5.5	8.1	6.9	7.0	6.2
4.7	2.9	5.9	1.1	3.5	9.1	2.4	4.0	3.5	2.9	2.1	6.8	5.5	5.4	5.9	2.9
5.9	6.7	6.6	4.8	6.0	8.0	5.9	7.9	1.4	9.7	8.7	2.8	6.2	5.1	8.0	1.8
7.7	6.7	2.1	8.4	7.5	5.4	7.2	1.0	4.7	4.4	6.7	1.7	5.8	3.6	4.7	6.7
1.0	8.2	8.9	4.1	7.0	5.0	7.4	6.1	9.3	1.4	2.4	1.1	4.7	4.5	2.0	7.0
3.0	5.1	9.2	3.6	1.9	1.1	8.3	1.3	4.8	9.2	6.2	2.2	2.4	5.6	8.8	3.9
2.6	2.9	2.2	6.4	2.1	7.5	10.0	2.8	7.4	5.2	3.8	5.7	6.3	6.8	6.7	4.3
5.4	1.9	4.1	8.7	1.0	9.5	1.2	7.0	2.5	7.7	1.7	6.1	3.8	3.9	6.3	6.1
6.6	1.3	2.0	2.8	4.0	2.9	6.0	1.1	1.2	4.1	3.4	4.9	3.3	4.4	2.6	3.7
3.7	6.5	9.9	2.2	1.3	9.7	8.0	1.9	6.3	1.6	3.3	5.9	9.0	1.3	7.0	6.0
4.8	7.8	8.1	3.5	9.2	3.3	8.4	2.4	9.3	1.5	4.7	2.4	6.6	5.5	5.9	4.0
Plot 41		Plot 42		Plot 43		Plot 44		Plot 45		Plot 46		Plot 47		Plot 48	
x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)
5.6	3.8	6.6	1.4	5.2	3.6	7.4	5.4	4.7	4.6	1.1	4.4	5.9	9.2	9.8	5.7
6.8	2.7	4.7	3.1	1.2	3.3	6.4	1.1	3.7	7.9	9.3	4.6	3.7	8.8	8.0	4.6
4.1	3.7	9.7	4.0	7.0	4.2	7.4	6.3	1.3	9.0	7.5	2.7	1.8	3.5	1.0	7.9
5.1	2.8	2.8	3.1	9.6	2.0	6.4	2.1	4.6	5.6	7.2	3.4	6.7	3.3	5.6	4.5
1.4	5.5	4.7	9.4	5.0	7.4	8.7	2.1	2.9	2.3	5.6	5.2	6.8	5.6	7.9	1.0
5.0	7.5	6.4	3.5	7.3	3.1	8.8	2.1	7.1	5.1	9.3	3.8	3.4	2.3	2.8	5.1
9.3	3.0	3.7	3.5	9.9	1.7	9.1	3.1	6.9	4.1	4.2	5.2	6.4	7.9	6.1	7.4
7.9	3.0	8.6	4.8	7.8	2.8	7.3	6.6	1.6	3.7	2.7	3.7	9.9	1.0	3.0	4.6
8.9	1.4	5.8	6.3	7.7	7.8	9.4	3.2	5.7	6.2	7.2	6.7	7.1	1.1	3.8	3.7
7.4	2.5	9.9	3.1	4.5	8.9	8.5	5.6	9.1	1.4	9.6	4.2	4.5	8.7	4.1	2.6
4.9	9.7	1.6	2.8	3.9	3.4	8.8	3.1	7.3	5.8	3.3	4.0	6.3	6.7	3.9	6.9
6.5	6.1	3.9	2.3	1.3	7.3	5.9	3.8	8.6	4.2	4.6	3.8	1.0	1.8	7.4	2.9
3.1	2.4	4.3	9.8	5.3	7.2	4.2	2.1	6.1	1.7	7.3	3.6	9.9	8.6	4.5	6.5
8.4	1.2	2.2	9.6	3.7	8.9	4.6	7.6	7.4	3.6	2.2	7.9	2.5	9.3	8.1	5.5
3.4	8.0	7.9	4.5	8.7	3.9	3.6	8.8	6.4	1.3	1.5	4.8	5.1	2.1	9.9	3.1
3.8	6.0	2.4	1.0	4.5	9.2	1.3	8.7	6.4	2.1	1.4	1.0	9.1	4.8	2.3	5.0
1.5	2.5	5.4	3.2	2.1	4.6	2.6	5.2	9.5	1.6	7.1	2.9	5.9	1.8	8.2	5.0
3.8	6.9	9.8	1.9	3.8	5.4	3.0	6.8	8.8	3.0	2.1	5.9	2.0	3.7	3.2	6.8
1.0	2.8	3.6	9.6	4.3	8.3	9.5	1.3	5.3	4.3	9.7	5.4	7.8	6.0	3.3	5.7
2.7	7.0	1.0	4.9	3.7	3.6	3.6	6.4	1.7	7.9	4.5	5.3	8.3	3.7	4.0	1.1

# EXAMPLE RANDOM NUMBERS FOR QUADRAT LOCATIONS-SLAG INVESTIGATION

Plot 49		Plot 50		Plot 51		Plot 52		Plot 53		Plot 54		Plot 55		Plot 56	
x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)
3.4	1.1	7.3	1.8	8.4	2.9	8.2	3.9	2.8	6.9	9.4	5.7	4.3	7.3	3.7	1.2
7.4	1.1	4.9	6.9	3.5	1.4	3.2	3.8	1.5	6.1	2.5	6.5	2.5	4.9	8.5	6.0
4.7	1.2	8.6	4.3	3.4	5.8	6.5	3.6	1.8	9.1	3.0	6.5	7.5	3.9	8.3	4.3
6.2	4.8	2.2	7.3	2.8	6.1	1.4	4.5	7.9	6.3	9.5	5.8	8.6	1.2	5.7	1.6
4.9	1.3	7.3	3.3	5.6	2.0	9.2	3.5	2.7	9.5	8	1.2	6.7	3.8	8.8	5.9
9.7	3.7	9.3	1.2	2.3	8.1	8.5	4.9	7.4	5.8	6.9	4.7	2.6	7.0	4.3	4.8
6.0	1.1	2.1	2.2	2.1	2.0	1.1	2.4	2.5	3.5	9.8	8.3	3.1	1.6	1.6	2.6
5.5	4.9	5.1	8.0	6.4	4.3	7.0	3.3	4.7	7.1	6.8	1.0	3.1	9.7	1.7	2.8
6.1	3.0	7.0	1.6	2.0	9.5	9.3	1.1	3.2	5.6	8.5	1.8	2.7	8.7	6.5	4.0
6.0	4.3	8.2	1.6	3.0	2.3	4.1	6.1	9.0	2.9	2.3	6.9	8.7	2.6	5.9	4.2
7.2	7.8	3.7	1.5	8.5	3.5	6.6	4.9	9.1	1.3	8.4	3.6	2.2	6.5	4.6	8.9
8.3	1.9	7.6	6.9	8.0	3.9	2.5	1.3	5.5	9.5	9.8	4.7	2.9	4.5	4.6	7.8
4.8	2.0	8.7	3.7	3.1	4.3	5.3	3.3	4.6	4.9	9.8	2.7	3.1	5.6	2.7	6.8
9.9	3.7	5.5	1.4	8.5	1.4	6.8	2.5	2.4	7.1	3.9	1.1	6.5	2.5	7.5	7.9
4.7	3.5	5.5	1.3	2.3	1.5	6.3	7.2	2.2	1.5	9.5	7.1	3.2	4.8	4.5	6.2
4.7	8.3	9.0	3.4	5.0	2.5	5.2	7.4	9.8	4.8	4.7	1.7	5.3	1.7	9.5	1.1
3.1	5.2	5.8	4.0	8.5	2.7	5.1	6.8	9.7	1.3	7.6	2.1	2.5	4.7	1.6	7.4
1.0	2.4	3.3	7.9	3.5	6.2	6.8	5.5	7.4	6.6	1.0	1.3	6.1	1.4	6.7	3.6
3.2	1.2	4.0	2.0	4.3	4.6	2.2	6.4	2.1	3.3	6.4	5.6	3.7	3.1	7.4	4.7
5.1	1.0	5.8	3.0	2.1	3.6	9.8	3.7	2.1	1.5	1.0	8.6	8.4	5.9	6.5	6.2
Plot 57		Plot 58		Plot 59		Plot 60		Plot 61		Plot 62		Plot 63		Plot 64	
x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)
7.6	2.8	5.8	9.5	1.6	3.9	5.8	2.7	6.1	1.2	6.5	3.2	2.8	4.6	3.6	9.2
8.8	1.1	3.6	2.5	6.1	5.1	3.7	7.5	4.0	7.2	2.9	9.5	6.4	5.3	9.5	2.4
7.9	2.0	6.7	5.9	4.3	8.5	6.9	5.6	8.4	4.8	5.9	5.9	7.9	6.9	6.2	2.9
9.4	2.8	5.5	8.1	4.9	2.5	2.7	6.4	3.9	5.1	1.1	7.2	8.3	4.5	8.4	3.2
9.3	3.6	1.5	2.9	3.5	1.0	7.9	2.6	1.3	6.3	5.5	3.0	4.3	9.5	2.9	4.8
3.0	3.9	10.0	1	4.9	9.8	2.1	3.0	2.3	3.2	5.7	1.6	7.5	2.0	5.3	1.5
7.1	7.8	6.8	8.5	3.6	4.5	4.5	6.9	8.5	1.3	5.3	5.5	1.3	5.1	9.5	3.2
7.1	6.9	4.3	1.4	3.0	7.3	5.3	9.6	9.7	4.8	5.8	8.2	6.4	6.2	8.8	8.7
6.1	6.7	4.6	7.5	6.0	8.2	7.9	7.3	2.6	3.8	4.3	9.5	1.1	5.4	6.8	1.4
1.1	7.0	1.6	1.0	9.7	1.2	7.8	2.8	8.3	1.4	6.7	1.3	3.0	6.4	2.4	4.8
2.7	8.8	8.9	3.5	7.2	4.5	9.6	1.2	10.0	2.6	3.1	5.4	7.5	3.6	7.4	1.4
4.7	4.9	9.3	2.7	9.8	1.5	3.0	7.8	7.6	2.5	6.3	9.2	1.8	6.0	5.0	9.4
4.6	1.6	4.1	2.9	5.7	3.5	4.4	8.0	3.7	7.6	5.9	3.2	1.5	2.1	8.5	6.1
2.9	8.3	3.7	2.4	8.6	4	9.1	2.9	4.6	3.6	5.2	1.5	3.7	2.0	7.8	2.9
2.6	8.3	9.6	2.8	6.0	1.2	3.7	1.8	2.8	5.3	5.6	1.1	6.3	8.6	8.3	3.2
1.6	5.8	8.6	6.6	8.5	3.0	5.4	4.5	8.1	1.5	8.8	3.6	1.0	8.3	5.7	6.3
5.2	1.5	8.8	1.7	1.4	3.6	4.9	2.7	4.2	9.5	5.8	2.2	8.5	3.5	7.7	7.7
9.6	6.7	1.6	1.8	5.4	1.4	3.7	5.7	3.2	8.2	6.8	4.2	4.4	3.5	6.6	1.9
3.6	2.0	8.8	5.4	3.5	2.7	3.5	7.0	2.9	5.7	3.7	4.8	6.7	7.8	6.4	3.2
3.3	4.4	1.7	3.8	8.8	1.1	2.2	1.5	9.8	2.6	9.8	2.5	7.7	5.8	1.7	6.3

# EXAMPLE RANDOM NUMBERS FOR QUADRAT LOCATIONS-SLAG INVESTIGATION

Plot 65		Plot 66		Plot 67		Plot 68		Plot 69		Plot 70		Plot 71		Plot 72	
x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)
4.2	8.3	9.5	1.4	3.4	4.0	6.1	2.3	2.4	5.1	3.1	9.6	4.4	7.0	4.3	4.2
3.6	4.1	2.3	1.1	2.8	7.6	8.0	1.5	5.4	3.5	5.9	6.7	5.5	5.8	4.1	3.9
4.7	1.0	2.9	6.6	7.8	4.2	3.1	3.1	3.2	2.8	8.1	1.8	4.9	8.8	2.0	5.5
3.5	2.5	2.4	6.7	3.4	9.4	1.9	3.4	9.4	4.3	9.6	2.5	1.3	1.4	7.1	5.8
3.6	1.3	3.5	8.5	7.7	1.6	9.5	1.7	4.3	7.7	2.1	8.0	9.4	1.0	2.6	2.3
1.1	6.8	7.2	3.6	3.1	8.2	4.5	1.7	2.3	4.4	8.0	5.3	9.9	1.1	3.0	8.8
5.4	4.3	2.0	6.1	7.1	1.0	7.6	1.4	3.1	4.9	1.5	7.4	1.8	7.9	7.4	4.6
4.8	4.1	9.6	4.5	3.9	9.5	4.7	9.8	1.8	4.1	9.2	1.1	5.2	4.5	9.6	2.7
1.3	8.7	1.0	3.4	2.4	6.1	2.5	4.7	7.3	2.6	8.1	2.3	6.3	8.4	3.5	3.3
6.6	7.1	1.1	3.5	1.8	4.0	6.6	5.7	9.4	1.0	8.2	2.1	3.5	1.5	2.0	8.7
8.6	4.7	1.2	6.0	7.1	7.6	4.5	6.1	5.3	9.1	9.2	5.8	7.8	4.3	3.0	6.7
6.6	4.7	4.1	9.3	6.2	4.2	2.3	6.0	1.4	3.7	2.5	2.5	6.8	4.1	3.0	6.3
2.9	1.6	9.6	4.6	4.2	9.4	3.4	1.9	2.7	2.9	2.3	6.0	9.1	2.0	10.0	2.0
9.4	4.4	5.2	9.6	2.8	1.6	8.9	1.7	3.5	4.7	7.0	3.4	7.1	7.1	7.4	7.8
7.3	7.5	3.9	5.9	8.5	4.8	1.0	2.9	8.9	3.4	8.6	3.3	7.7	2.6	4.6	7.7
1.4	9.2	3.3	1.8	7.9	1.7	8.1	2.5	4.9	8.6	6.1	3.8	9.1	3.0	5.0	8.7
8.5	2.6	9.6	6.0	8.7	2.0	5.9	7.0	3.3	5.1	9.5	3.3	4.8	7.4	8.3	2.5
2.4	1.5	6.2	1.2	9.6	2.5	4.5	9.4	2.3	7.8	7.5	3.2	9.9	2.7	1.6	1.6
8.7	3.9	5.9	3.6	9.5	2.0	2.7	6.0	7.1	1.9	1.4	1.0	5.7	3.5	1.3	7.8
2.7	1.7	2.6	6.4	6.1	7.2	5.0	1.9	3.3	6.5	6.0	6.9	7.5	2.0	5.5	4.9
Plot 73		Plot 74		Plot 75		Plot 76		Plot 77		Plot 78		Plot 79		Plot 80	
x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)
9.9	1.7	9.4	1.3	3.5	6.3	2.9	4.6	6.3	8.0	2.0	5.7	5.5	2.8	2.1	7.7
2.1	7.4	7.4	1.8	1.3	9.1	9.0	2.8	3.4	3.7	2.7	1.4	5.4	3.9	5.5	5.9
6.0	2.1	7.4	2.7	9.4	5.2	3.4	2.2	2.3	2.3	9.1	3.0	6.5	7.1	4.2	4.8
5.2	9.4	4.5	1.3	2.0	8.2	9.6	3.7	5.9	5.6	6.5	3.2	8.0	2.9	7.1	2.8
7.1	2.7	7.6	7.2	7.2	5.1	2.8	9.3	5.2	4.3	8.3	4.6	9.9	1.1	5.9	2.1
3.8	5.4	2.7	3.5	3.7	9.6	2.4	5.0	3.1	4.4	3.2	2.4	5.1	1.5	6.9	5.6
3.5	5.7	1.9	7.5	7.7	1.6	7.7	4.6	8.8	3.3	2.6	3.6	9.8	3.5	6.6	6.4
7.8	1.4	3.2	8.6	5.2	2.8	9.9	3.7	7.3	6.5	5.0	7.2	1.4	1.0	6.0	1.2
6.6	8.0	9.7	1.9	8.7	3.5	8.5	3.5	4.4	4.3	1.9	7.9	6.3	2.1	7.2	7.2
2.0	3.0	6.5	3.8	9.7	3.3	6.3	8.1	9.1	2.8	3.5	6.9	4.4	9.7	8.5	3.7
7.7	4.9	7.8	1.3	2.8	4.1	2.4	2.1	8.9	4.6	1.7	6.1	6.6	3.7	5.1	6.5
3.5	9.3	5.5	1.7	8.3	1.6	4.7	5.5	2.9	8.0	1.9	6.2	2.3	5.9	8.2	2.1
4.0	2.0	9.0	1.2	2.7	5.2	4.4	9.7	7.1	3.0	1.5	2.3	2.4	3.4	6.1	4.4
3.8	1.2	6.0	5.6	5.6	3.9	6.6	2.5	2.1	9.4	4.0	2.8	3.1	5.6	3.4	9.5
4.8	7.0	1.1	1.3	4.2	7.6	1.0	3.4	9.7	2.2	5.7	3.2	3.7	7.7	5.2	3.9
1.9	4.9	5.2	4.9	4.4	4.2	2.6	9.1	2.9	6.4	6.8	3.0	1.8	3.9	3.2	7.2
5.5	5.8	7.9	7.7	7.1	3.5	4.1	3.1	4.4	3.4	8.1	4.9	1.4	8.6	6.7	1.1
6.2	1.0	5.9	2.9	2.3	1.4	9.0	4.0	4.4	7.0	2.6	6.4	7.7	5.2	5.2	7.4
7.5	1.6	4.8	9.0	2.7	3.7	7.3	4.1	9.7	1.7	1.0	8.6	1.8	9.2	1.5	5.7
5.6	9.9	5.2	5.7	3.9	3.6	3.2	4.0	9.3	3.3	3.8	6.5	2.4	9.6	5.7	1.5

# EXAMPLE RANDOM NUMBERS FOR QUADRAT LOCATIONS-SLAG INVESTIGATION

Plot 81		Plot 82		Plot 83		Plot 84		Plot 85		Plot 86		Plot 87		Plot 88	
x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)	x-axis (m)	y-axis (m)
8.9	5.2	1.1	7.7	3.4	8.5	4.7	2.5	2.4	8.1	8.4	2.2	7.7	3.5	1.8	9.0
6.5	6.1	7.8	4.4	4.2	7.3	8.7	4.9	1.6	6.0	9.3	3.8	2.8	4.0	9.0	5.1
6.0	7.8	1.0	5.5	3.0	6.7	3.8	7.5	3.7	8.4	5.1	5.6	1.6	1.3	6.7	4.2
7.7	3.8	2.5	9.0	8.0	3.0	2.9	1.7	5.1	4.0	1.0	2.0	3.9	1.9	7.0	1.8
1.0	2.6	9.5	5.9	5.1	5.4	7.7	5.4	5.2	7.5	8.5	6.0	8.5	2.4	1.1	7.3
2.6	4.4	3.4	1.3	7.2	7.1	1.4	8.7	9.1	2.2	9.7	1.3	2.2	2.4	8.2	2.6
8.9	2.9	1.8	6.7	2.2	3.9	6.9	6.6	9.7	1.8	9.7	3.4	5.9	8.7	5.7	4.8
5.6	7.9	6.4	4.7	1.3	6.1	5.6	8.9	1.9	9.6	5.8	6.6	2.0	8.3	4.7	3.7
6.3	6.6	9.0	3.1	2.7	4.9	2.4	3.7	9.3	1.3	2.6	4.6	4.4	2.7	7.5	6.5
9.8	3.1	2.5	6.7	8.6	2.9	1.3	1.8	2.3	1.5	3.7	6.9	7.2	1.1	4.1	8.6
5.1	1.4	1.1	1.6	9.9	3.4	9.6	4.5	3.0	4.1	9.9	1.4	5.1	2.5	1.2	8.0
4.8	4.8	2.9	4.2	7.2	2.0	4.3	5.2	3.1	8.0	6.0	1.6	2.3	9.7	7.6	7.5
6.2	2.7	3.4	2.0	7.6	2.5	7.8	2.8	6.4	4.6	6.4	6.9	5.9	6.9	1.0	5.8
3.7	4.2	6.3	2.2	9.3	6.3	3.6	9.2	5.9	9.0	9.8	3.2	9.7	2.3	2.5	3.3
1.4	1.0	2.7	3.7	5.3	3.0	4.1	7.9	2.2	7.8	2.1	4.2	7.3	3.6	8.6	3.8
4.0	7.3	9.5	1.1	1.3	3.9	4.3	1.9	2.2	9.6	4.7	4.6	7.6	3.7	5.1	3.3
8.5	4.8	2.3	7.6	8.8	4.2	4.4	4.9	7.5	4.3	6.5	6.1	2.9	7.1	3.6	4.0
1.3	8.3	9.7	1.3	5.1	9.5	1.3	4.7	2.0	8.2	8.0	1.4	2.7	3.1	5.5	8.6
9.5	1.1	8.2	5.1	1.0	2.8	3.8	9.8	2.7	4.8	3.5	1.6	5.0	9.3	3.7	7.3
4.0	9.7	3.7	5.3	8.7	4.6	9.0	7.3	6.2	4.7	8.6	2.3	8.8	1.9	7.7	7.3

## Extra Random Numbers

1.0	4.5	1.6	4.0	7.9	7.9	4.7	6.0	9.1	9.1	2.1	3.8	7.3	2.2	5.1
0.5	9.0	3.3	8.0	2.8	7.7	9.7	7.8	3.8	3.9	4.2	1.9	6.9	3.0	8.3
2.2	3.3	8.7	2.6	2.6	1.7	1.3	5.0	1.8	7.6	2.8	1.1	7.6	8.0	5.0
0.3	0.7	4.2	7.7	1.4	6.4	6.6	4.2	9.5	0.6	3.3	7.0	2.9	2.1	9.6
5.1	9.1	5.7	8.1	10.0	6.5	2.7	7.3	5.3	0.3	3.1	6.0	0.9	9.0	0.0
8.2	5.4	5.0	9.9	7.0	1.1	7.0	8.2	6.6	2.0	10.0	2.2	0.2	7.5	3.7
9.3	3.9	8.0	0.1	4.4	5.6	4.3	0.7	3.0	3.4	8.9	8.8	9.3	9.7	4.6
2.5	6.2	4.6	8.5	6.7	6.8	1.1	6.7	3.3	6.3	7.5	5.3	2.7	1.3	0.6
6.9	8.1	6.0	6.1	6.9	4.9	7.9	7.5	4.9	5.6	3.1	3.2	6.4	0.0	3.3
0.6	1.1	0.9	6.2	5.7	7.0	3.8	0.4	2.4	8.8	4.4	0.0	7.3	7.5	1.2
6.8	3.2	8.0	9.4	7.0	5.7	0.8	8.2	5.0	9.7	8.3	2.0	3.3	0.7	1.7
6.9	2.5	0.3	3.3	10.0	3.3	7.6	7.5	3.4	2.5	5.1	5.7	7.6	7.5	9.0
2.7	6.0	0.5	9.9	4.9	1.3	9.5	4.5	1.5	5.8	0.2	2.3	1.2	6.6	8.5
6.9	6.1	5.8	4.6	5.5	1.1	1.5	9.5	6.5	8.5	3.7	2.5	1.1	5.0	0.2
5.0	2.1	5.7	7.3	5.1	3.2	7.5	3.0	7.8	4.7	0.6	7.6	3.7	4.9	3.6
7.2	8.9	5.5	2.3	4.6	5.9	0.4	2.5	1.5	6.3	9.7	4.5	8.4	3.7	2.5
1.2	0.8	5.3	8.5	0.1	1.3	7.8	8.1	7.8	4.2	9.8	9.1	4.8	5.8	7.2
3.5	3.2	8.1	1.5	8.2	0.9	7.1	4.6	0.2	5.9	1.6	9.6	3.7	0.2	7.8

**QUANTITATIVE FLORISTIC SURVEY – FIELD DATA SHEET**  
**GROUND LAYER VEGETATION**

**Project Name:** \_\_\_\_\_ **ELM Project #:** \_\_\_\_\_ **Investigator(s):** \_\_\_\_\_

**Transect :** \_\_\_\_\_ **Plot #:** \_\_\_\_\_ **Date/Time:** \_\_\_\_\_ **Habitat Type:** \_\_\_\_\_

Daubenmire Cover Scale: 1=0-1%; 2=2-5%; 3=6-15%; 4=16-25%; 5=26-50%; 6=51-75%; 7=75-100%

[illegible]

Notes/Comments: \_\_\_\_\_

Project Name: \_\_\_\_\_

ELM Project #: \_\_\_\_\_

Transect : \_\_\_\_\_ Plot #: \_\_\_\_\_

Date/Time: \_\_\_\_\_

Investigator(s): \_\_\_\_\_ Habitat Type: \_\_\_\_\_

Notes/Comments: \_\_\_\_\_



## **Standard Operating Procedure (#99-0034-SOP-08) for Collecting Dissolved Oxygen Data in Freshwater Ecosystems**

### **1 Scope & Summary**

This protocol outlines the procedures for collecting dissolved oxygen (DO) data in the field from aqueous samples.

### **2 Reference Documents**

Orion Research, Inc., 1996. Instruction Manual for Model 842 Dissolved Oxygen Meter.

### **3 Significance and Use**

The data generated by these guidelines are considered Level II or screening data. While these data are scientifically defensible and can be used to aid in the decision-making process in the field, they may not withstand legal scrutiny in court proceedings.

### **4 Potential Interferences**

- 4.1 Damage to or contamination of the probe membrane can cause erratic results. Erratic results also occur when the probe no longer contains electrolyte solution. When this happens, refer to the instruction manual for the meter for probe servicing requirements and procedures.
- 4.2 High salt concentrations in the samples can affect the accuracy of meter readings. This can be corrected by setting the salinity correction factor in the meter.
- 4.3 If the sample is exposed to air and/or excessive turbulence, the reading will be biased high.

### **5 Apparatus and Materials**

- Orion Model 842 dissolved oxygen meter and probe. NOTE: galvanic probes are preferred due to the elimination of polarization time required after the connection of the probe to the meter.
- reagent-grade water

### **6 Hazards & Precautions**

- 6.1 Samples might contain potentially toxic materials, and thus should be treated with caution to minimize exposure to workers. Gloves are recommended.
- 6.2 The project Health and Safety Plan must be reviewed to identify further hazards, precautions and safety procedures.
- 6.3 Caution should always be exercised while sampling near water. A personal flotation device should be worn if the water body being sampled is deep enough for a person to drown.
- 6.4 As a result of the potential for electrocution, the investigator should cease sampling if thunder and lightning is present while sampling water bodies for temperature and dissolved oxygen.

### **7 Calibration and Standardization**

- 7.1 The dissolved oxygen meter/probe system must be calibrated at least once per day according to manufacturer specifications. All information regarding the calibration of the meter/probe system (e.g., date, time, initials of field personnel,

and final slope value) must be documented on appropriate field equipment calibration forms.

7.2 The following table summarizes the calibration and standardization information of the DO meter:

QC Measures	Calibration Frequency	Acceptance Criteria	Correction Action	Decontamination Procedures
Field Duplicate, freq. of 10%	Beginning of each work day/freq. of 10% thereafter	Criteria hard-wired into system; "E3" error message	Clean sensor and replace membrane and electrolyte	Rinse thoroughly with DI water

## 8 Procedures for Dissolved Oxygen Measurement of Aqueous Samples

- 8.1 When collecting dissolved oxygen data, care should be taken to eliminate the exposure of the sample to air prior to measurement. Sample collection procedures should be designed to minimize sample agitation, as well. Dissolved oxygen readings should be collected as the sample is slowly pumped through a closed system, such as a flow-through cell. If a closed system is not available, dissolved oxygen readings may be biased high.
- 8.2 After immersion of the probe into the sample, make sure that sufficient sample flow is present during measurement. This can be accomplished by gently moving the sensor by hand or by attaching a stirrer to the sensor. When the meter senses that the reading is stable, STABLE or READY will appear on the meter display. Record the dissolved oxygen measurement on the appropriate sample data form.
- 8.3 Decontaminate the cell between samples by thoroughly rinsing the electrode with reagent water. Between readings or between sampling events, the probe should be stored in the calibration sleeve with moisture in the water reservoir.

## 9 Calculations Not Applicable

### Applicable Forms

Surface Water Sampling field Data Sheet

Dissolved Oxygen Meter Calibration Sheet

[illegible]



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Barrington, Illinois 60010

### Surface Water Sampling Field Data Sheet

Project Description		Field Team Leader	
Project No.	Date	Time	
Sampling Personnel			
Sample ID			
Description of Sample Location & Observations			
Sunny <input type="checkbox"/>	Partly Sunny <input type="checkbox"/>	Cloudy <input type="checkbox"/>	Raining <input type="checkbox"/>
Calm <input type="checkbox"/>	Slightly Windy <input type="checkbox"/>	Windy <input type="checkbox"/>	Gusting Winds <input type="checkbox"/>
Ambient Air Temperature (°F):		Flow:	
Specific conductance (µmhos)		Water temperature (°C)	
pH		Dissolved oxygen (mg/L)	
Water samples collected (check)		Redox:	
<input type="checkbox"/>	volatile organic compounds	<input type="checkbox"/>	volatile organic compounds
<input type="checkbox"/>	semi-volatile organic compounds	<input type="checkbox"/>	semi-volatile organic compounds
<input type="checkbox"/>	priority pollutant pesticides	<input type="checkbox"/>	polychlorinated biphenyls
<input type="checkbox"/>	total organic carbon	<input type="checkbox"/>	Other _____
<input type="checkbox"/>	particle size distribution	<input type="checkbox"/>	Other _____
Comments			



## **Standard Operating Procedure (#99-0034-SOP-09) for Collecting Slag Samples from the Slag Pile Storage Area at the Doe Run Company Lead Smelter-Herculaneum, Missouri**

### **1. Scope & Summary**

This standard operating procedure (SOP) outlines techniques for collecting shallow (0"-6") and deep (6 feet and deeper) slag samples from the slag pile storage area located on the property of The Doe Run Company, Herculaneum, Missouri lead smelter. The samples are described as "grab" samples, because they represent a discrete aliquot taken from one specific sampling location at a specific point in time. Shallow slag samples are collected using a hand-held, plastic, disposable plastic scoop sampler. Deep slag samples are continuously samples using a hollow-stem auger with a split-spoon sampler. Samples are placed into laboratory-certified, pre-cleaned and pre-labeled jars with minimum headspace and packed in ice (in coolers) during transportation to the laboratory.

### **2. Reference Documents**

- 2.1. ASTM (1997) *ASTM Standards on Environmental Sampling*, 2<sup>nd</sup> ed. W. Conshohocken, PA.
- 2.2. Cox, Doyle B. (2000) *Hazardous Materials Management - Desk Reference Guide*. Academy of Hazardous Materials Managers, McGraw Hill, Inc.
- 2.3. Soil Science Society of America (1985) *Water Potential Relations in Soil Microbiology*, SSSA Special Publication No. 9, Madison, WI.
- 2.4. USEPA (1987) *A compendium of Superfund Field Operations Methods*. EPA/540/P-87/001. U. S. Environmental Protection Agency.
- 2.5. U.S. Environmental Protection Agency, (USEPA, third edition). *SW-846 Test Methods for Evaluating Solid Wastes-Physical/Chemical Methods*. Office of Solid Waste.

### **3. Significance and use**

The samples collected by this method are suitable for chemical characterization. Quantitation limits are limited to those outlined in the U.S. EPA, Office of Solid Waste SW-846 Test Methods for Evaluating Solid Wastes. The protocol described herein is not an "ultraclean" sampling protocol requiring "clean-hands dirty-hands" techniques. Rather, the sampling method is typical to that of the environmental industry where disposable, single-use, non-talc, PVC gloves are worn during sampling activities only. The analytical results from grab samples collected using this method should provide a good representation of the concentration of contaminants present at the point and time the sample was collected. The results will be used to evaluate chemical concentrations in the slag at the sampling locations.

This SOP is submitted to the United States Environmental Protection Agency (USEPA) and the Missouri Department of Natural Resources (MDNR) by The Doe Run Resources Corporation (Doe Run) pursuant to the Administrative Order on Consent - Docket No.

VII-99- (AOC). This SOP has been written to fulfill requirements outlined in the AOC. The AOC and this Plan concern the slag pile storage area of the Doe Run lead smelter at 881 Main Street in Herculaneum, Jefferson County, Missouri as well as slag pile/surface water/sediment/groundwater areas affected by the operation of the slag pile.

#### **4. Potential Interferences**

There are numerous routes by which samples may become contaminated. Potential sources of inorganic contamination during sampling include metallic or metal-containing sampling equipment, containers, labware (e.g. talc gloves that contain high levels of zinc), reagents, and deionized water, improperly cleaned and stored equipment, labware, and reagents; and atmospheric inputs such as dirt and dust from automobile exhaust, cigarette smoke, nearby roads, bridges, wires, and poles.

- 4.1. The slag pile surface may not be homogeneous. This lack of homogeneity may result in sampling and analytical bias that results from ease of sample collection in the field as well as aliquot acquisition in the lab. Therefore, efforts should be made to collect representative slag from the sample location that minimizes the occurrence of large objects (sticks, stones, etc.) that may influence the results of the analysis.
- 4.2. Differences in slag moisture content may bias the results of contaminant concentrations on a micro-scale at a sample location. Slag moisture content may be a result of the physical movement of water through or over slag, and is known to play an important role in the dynamics of slag microbiology. As a result, concentrations of contaminants observed in soil may be an artifact of leaching, deposition and/or microbial activity. Therefore, an attempt is made to collect slag with similar water content within a given sampling location.
- 4.3. When sampling with a hollow stem/split-spoon apparatus, it is imperative to decontaminate the split-spoon sampler thoroughly to avoid cross contamination between depths and between sample locations. The split-spoon should be decontaminated before the first sample is collected at the beginning of the day and between each sample collected thereafter. The sampling split-spoon sampler should be decontaminated with aalconox/potable water wash, followed by a potable water rinse. Deionized water is then used as the final wash, followed by an optional rinse in isopropanol (using a spray bottle).

#### **5. Apparatus**

##### **5.1. Surface Slag Sampling**

- 5.1.1. The hand-held, disposable plastic sample scoop is contained within a plastic wrapper, so that it does not contact anything other than the matrix to be sampled.
- 5.1.2. Disposable, non-talc, PVC gloves are used by the sample team, to minimize the occurrence of cross contamination between sample points or between materials contacted by the sampling team that are not intended to come in contact with the sample.

##### **5.2. Sampling slag at depth greater than six (6') feet**

SOP for Collecting Slag Samples from the Slag Pile Storage Area at the Doe Run Company Lead Smelter-Herculaneum, Missouri

Revision, 1.0, 11-January-01

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- 5.2.1. Drill rig and associated field equipment (hollow stem augers, split-spoon samplers, pipe wrenches, isopropanol, decon water, etc).
- 5.2.2. The hand-held, disposable plastic sample scoop is contained within a plastic wrapper, so that it does not contact anything other than the matrix to be sampled.
- 5.2.3. Disposable, non-talc, PVC gloves are used by the sample team, to minimize the occurrence of cross contamination between sample points or between materials contacted by the sampling team that are not intended to come in contact with the sample.

## **6. Materials**

- Disposable plastic sample scoop sealed in a plastic wrapper
- Sample containers with lids of type consistent with the requested analytical methods
- Sample labels
- Waterproof marking pens/pencils
- Non-talc, PVC gloves
- Cooler
- Sample data forms/clip board
- Camera and film
- Personal safety gear
- Compass
- Miscellaneous tools (utility knife, vise grip pliers)
- Photo-ionization detector (PID)
- Drill rig and associated equipment
- Decon water, buckets and brushes
- Isopropanol spray bottle

## **7. Hazards & Precautions**

- 7.1. Field-collected slag might contain potentially toxic materials, and thus should be treated with caution to minimize exposure to workers. Appropriate clothing and gloves are recommended.
- 7.2. The project Health and Safety Plan must be reviewed to identify further hazards, precautions and safety procedures while sampling slag.
- 7.3. Collecting samples in cold weather, especially around cold water bodies, carries the risk of hypothermia, and collecting samples in extremely hot and humid weather carries the risk of dehydration and heat stroke. Sampling team members should wear adequate clothing for protection in cold weather and should carry an adequate supply of water or other liquids for protection against dehydration in hot weather.
- 7.4. Collecting samples in cold weather, especially around cold water bodies, carries the risk of hypothermia, and collecting samples in extremely hot and humid weather carries the risk of dehydration and heat stroke. Sampling team members should wear adequate clothing for protection in cold weather and should carry an adequate supply of water or other liquids for protection against dehydration in hot weather.

- 7.5. Caution should be taken while working around heavy machinery. The appropriate personal protective equipment (hard hat, steel-toe boots, gloves, etc.) should be worn while collection slag samples with a hollow-stem auger/split-spoon sampling apparatus.

## **8. Sample Preparation**

- 8.1. Sample locations may be adjusted on-site as deemed necessary by the location of sedimentation zones, physical obstructions, or other factors. A pre-sampling site inspection should be conducted to evaluate whether these procedures are feasible for sampling the desired locations.
- 8.2. Appropriate new sample containers must be obtained from the analytical laboratory or a commercial supplier. The analytical procedures must be reviewed to identify the proper sample container material, size, and preparation.
- 8.3. The Field Team Leader must read the Quality Assurance Project Plan before field sampling procedures are undertaken to understand how many and what type of QA/QC samples are required.
- 8.4. The Field Team Leader must read the Health and Safety Plan prior to sampling to review applicable safety requirements.

## **9. Preparation of Apparatus**

- 9.1. The field equipment should be assembled into the equipment cooler prior to departure.
- 9.2. The drill rig should be tested prior to sample collection to make sure that all machinery is functioning properly (hydraulic lines, engine, hammer, etc.).

## **10. Calibration & Standardization**

- 10.1. No equipment calibration is required for sampling of surface slag or deep slag using a hollow stem auger/split-spoon sampling apparatus.

## **11. Procedure**

### **11.1. Sampling surface slag**

11.1.1. Site Selection – See Work Plan.

11.1.2. Sampler and assistant will don non-talc, PVC gloves prior to sample collection.

11.1.3. Assistant will label sample jars and the sampler will prepare sample equipment (remove scoop from outer wrapping) to collect sample from sample location.

11.1.4. Samplers observe sample location. If debris (leaves, twigs, etc) are located in the sampling area, move to an adjacent area without debris.

11.1.5. Sampler will unearth slag to a depth pre-determined in the Sampling and Analysis Plan (SAP) associated with this investigation (surface slag or a few inches below surface slag) with plastic scoop and place slag sample into sample jar. The sampler will immediately place lid upon jar, and wipe excess material from outside of jar. Sample jar will then be placed into plastic bubble-wrap bag and placed into cooler containing ice.

11.1.6. Sample scoop and PVC gloves will be disposed of in a trash bag. No other decontamination will be necessary.

11.1.7. Samples will be recorded on a chain-of-custody form and placed into the cooler containing the samples, so that the chain-of custody form accompanies the samples for which it is prepared.

11.1.8. Assistant will take photographs of the sample location, and photographs in a direction both up-slope and down-slope from the sample location. Location of sample will be noted on map and verbally described on field data sheet. Photographs of sample consistency will also be documented.

11.1.9. Assistant will record compass readings between sample points and other significant features on field data sheets.

11.1.10. Sample cooler is packed and shipped according to laboratory and shipper protocols.

## 11.2. Sampling Subsurface Slag

11.2.1. Site Selection - See Work Plan.

11.2.2. Sampling crew shows the drilling crew where to begin drilling with the hollow-stem auger (HAS) apparatus.

11.2.3. A two to four-foot split-spoon sampler, which is a hollow steel tube split longitudinally down its length to create two halves, is driven ahead of the cutting head at the bottom of the augers in order to retrieve relatively undisturbed slag. The split-spoon is driven to a pre-determine depth (see SAP) to retrieve a sample.

11.2.4. Sampler and assistant will don non-talc, PVC gloves prior to sample collection.

11.2.5. Assistant will label sample jars and the sampler will prepare sample equipment (remove scoop from outer wrapping) to collect sample from sample location.

11.2.6. After driving is completed, the split-spoon sampler is withdrawn and the shoe and coupling are removed. The slag sample collected inside the split tube may then be screened for contamination with a PID and logged on the boring log.

11.2.7. Sampler collects sample from the split-spoon with plastic scoop and places slag sample into sample jar. The sampler will immediately place lid upon jar, and wipe excess material from outside of jar. Sample jar will then be placed into plastic bubble-wrap bag and placed into cooler containing ice.

11.2.8. Sample scoop and PVC gloves will be disposed of in a trash bag. Drilling crew decontaminates split-spoon as described in Section 4.3.

11.2.9. Samples will be recorded on a chain-of-custody form and placed into the cooler, on ice, containing the samples, so that the chain-of-custody form accompanies the samples for which it is prepared.

11.2.10. Assistant will take photographs of the sample location, and photographs in a direction both up-slope and down-slope from the sample location. Location of sample will be noted on map and verbally described on field data sheet. Photographs of sample consistency will also be documented.

11.2.11. Sample cooler is packed and shipped according to laboratory and shipper protocols.

**12. Calculations** Not Applicable

**13. Applicable Forms**

Field Data Form for Slag Sampling

Drilling Log

Audit Checklist for Slag Sampling

Audit Finding Report

Photograph Log

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 Barrington, IL 60010

### Slag Sampling Field Data Sheet

Project Description		Field Team Leader	
Project No.	Date	Time	
Sampling Personnel			
Sample ID			
Description of Sample Location & Observations			
Sunny <input type="checkbox"/>	Partly Sunny <input type="checkbox"/>	Cloudy <input type="checkbox"/>	Raining <input type="checkbox"/>
Calm <input type="checkbox"/>	Slightly Windy <input type="checkbox"/>	Windy <input type="checkbox"/>	Gusting Winds <input type="checkbox"/>
Ambient Air Temperature (°F): _____			
Specific conductance (µmhos) (if applicable)		Water temperature (°C) (if applicable)	
PH (if applicable)		Dissolved oxygen (mg/L) (if applicable)	
Slag samples collected (check)			
<input type="checkbox"/>	priority pollutant metals	<input type="checkbox"/>	Individual Metal _____
<input type="checkbox"/>	Skinner List of Inorganics	<input type="checkbox"/>	Individual Metal _____
<input type="checkbox"/>	total organic carbon	<input type="checkbox"/>	Individual Metal _____
<input type="checkbox"/>	Particle Size Distribution	<input type="checkbox"/>	Other _____
<input type="checkbox"/>	Individual Metal _____	<input type="checkbox"/>	Other _____
Comments			

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### Audit Checklist for Slag Sampling

Project Description	Field Team Leader
Project No.	Audit Date
Sampling personnel	Audit No.

Audit Question	S	U	N/A	comments
Were all personnel briefed on their assignment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Did the crew have all the forms and maps, equipment and materials necessary to complete the assigned tasks?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were the sampling locations correctly identified on the forms?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were the field meters properly calibrated?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were samples collected according to the procedure and all potential interferences addressed before sampling?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Was the depth of the sediment samples consistent?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were sample locations properly marked for the survey crew?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were the sampling equipment and meter probes properly cleaned between sample locations?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were all sample containers properly labeled?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were all sample containers properly filled (e.g. no head space)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were all samples properly packed for shipping?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
packed in ice?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
custody seals in appropriate places?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Did personnel adhere to the safety procedures?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Auditor Signature: \_\_\_\_\_



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Barrington, Illinois 60010

**Audit Finding Report**

Project No.	Task No.	Audit No.	Audit Date
Individual(s) contacted		Auditor Signature	
Requirements			
Findings			
Recommended Corrective Action			
Scheduled Response Date		Responsible for Corrective Action	
Corrective Action Taken			
Date	Submitted by	Management Approval	
Date Response Received		Response Acceptable?	Yes No
Reason for Rejection			
Verification			
Date Verified		Auditor Signature	

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 Barrington, Illinois 60010

### Photograph Log

Project Description		Field Team Leader	
Project No.	Task No.	Photos By	
Date(s)		Location	
Film Type		Roll/Disk #	of
Frame	Subject/Sample ID	Frame	Subject/Sample ID
1		19	
2		20	
3		21	
4		22	
5		23	
6		24	
7		25	
8		26	
9		27	
10		28	
11		29	
12		30	
13		31	
14		32	
15		33	
16		34	
17		35	
18		36	

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**DRILLING LOG**

Page      of

GEOLOGIST						BORING NUMBER
FACILITY / PROJECT						ELEVATION
DATE / TIME DRILLED						X,Y COORDINATES
DRILLING METHOD						TOTAL DEPTH
DRILLING COMPANY						DEPTH TO WATER
DEPTH (feet)	RECOVERY / INTERVAL (feet)	SAMPLE / MATRIX / TIME / ANALYSIS	MOISTURE CONTENT / DEPTH TO WATER	PID/ FID (ppm)	INTERFACE	DESCRIPTION AND REMARKS
1						
2						
3						
4						
5						
6						
7						
8						
9						
0						



## **Standard Operating Procedure (#99-0034-SOP-10) for the Collection of pH Data from Freshwater Ecosystems**

### **1 Scope & Summary**

This standard operating procedure (SOP) outlines the procedures for collecting pH data in the field from aqueous or non-aqueous samples. This SOP is to be utilized to collected pH data in freshwater ecosystems and is specifically designed for the Accumet AP Series Handheld pH/mV/Ion Meter.

### **2 Reference Documents**

Fisher Scientific, 1998. Instruction Manual for Accumet AP Series Handheld pH/mV/Ion Meter.

Orion Research, Inc., 1996. PerpHecT ROSS Electrodes Instruction Manual.

U.S. EPA, 1995. "Method 9040B - pH Electrometric Measurement." Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, Third Edition, Revision 2.

U.S. EPA, 1995. "Method 9045C - "Soil and Waste pH." Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, Third Edition, Revision 3.

### **3 Significance and Use**

- 3.1 The data generated by these guidelines are considered Level II or screening data. While these data are scientifically defensible and can be used to aid in the decision-making process in the field, they may not withstand legal scrutiny in court proceedings.
- 3.2 The protocols outlined in this SOP are to followed using only the Accumet AP Series Handheld pH/mV/Ion Meter with PerpHecT ROSS Electrodes.

### **4 Potential Interferences**

- 4.1 Samples with very low or very high pH may give incorrect readings on the meter. For samples with a pH of  $> 10$ , the measured pH may be incorrectly low. This error may be minimized using a low sodium error electrode. For samples with a pH of  $< 1$ , the measured pH may be incorrectly high.
- 4.2 Coatings of oily material or particulate matter can impair electrode response. These coatings can usually be removed by gentle wiping or detergent washing, followed by rinsing with deionized water. An additional rinsing with a hydrochloric acid solution (1:10) may be necessary to remove any remaining film.
- 4.3 Temperature fluctuations will cause measurement errors by the instrument. This interference can be controlled with instruments having temperature compensation or by calibrating the electrode-instrument system at the temperature of the samples. However, temperature fluctuations may also cause a change of pH within the sample. This error is sample-dependent and cannot be controlled. Therefore, it should be noted by recording both the pH and the sample temperature at the time of analysis.

- 4.4 The pH meter should be calibrated as directed by the instruction manual. If the meter is not properly calibrated prior to use, incorrect readings will be collected in the field.

## 5 Apparatus and Materials

- pH meter with means for temperature compensation;
- combination pH electrode with potassium chloride filling solution;
- pH buffer solutions of 4.01, 7.00, and 10.01. NOTE: Buffer solutions should be refrigerated, if possible, and must be replaced after six months of use;
- thermometer and/or temperature sensor for automatic compensation;
- beakers;
- analytical balance capable of weighing 0.1 g; and
- magnetic stirrer and teflon coated stirring bar.

## 6 Hazards & Precautions

- 6.1 Samples might contain potentially toxic materials, and thus should be treated with caution to minimize exposure to workers. Gloves are recommended.
- 6.2 The project Health and Safety Plan must be reviewed to identify further hazards, precautions and safety procedures.

## 7 Electrode Preparation

When using a combination pH electrode, uncover the filling hole and add filling solution, if necessary. The filling solution must always be above the reference junction within the electrode and at least one-inch above the sample level when immersed. Place the electrode in the electrode holder and suspend in air for 15 minutes to thoroughly wet the reference junction. Once the junction is wet, do not allow the electrode to dry out. Prior to use, soak the electrode in storage solution or buffer solution with a pH of 7 for one hour.

## 8 Calibration & Standardization

The pH meter must be calibrated according to manufacturer specifications. The meter/electrode system will be calibrated using a minimum of two points (buffer solutions) that bracket the expected pH of the samples and are approximately three pH units or more apart. Thoroughly rinse the electrode with reagent water prior to measuring the pH of each buffer solution and following calibration procedures. All information regarding the calibration of the meter/electrode system (e.g., date, time, buffer solutions used, initials of field personnel, and final pH slope reading) must be documented on appropriate field equipment calibration forms.

A calibration check should be performed once for every 10 investigative readings collected (or 10%). To perform a calibration check, follow the specifications outlined in the instructional manual or as outlined below. Buffer 7 should be used at a minimum to assure that the meter is functioning properly in the field.

- 8.1 Immerse the electrode(s) into the sample solution (buffer 7). Stir moderately if possible. Note: Make sure the meter is in the pH mode.
- 8.2 When the meter senses that the reading is stable, **STABLE** will appear under the measurement reading. The reading may be recorded at this time.

8.2.1 If **AUTO** is not displayed on the screen, the autoread function is not active, and the meter will continuously monitor the pH value of the sample, and change as it changes.

8.2.2 If **AUTO** is displayed on the screen, the meter will fix the measured pH value on the screen when it is stable. Press **enter** to obtain a new reading in the same or another sample. **AUTO** will flash on the display until a stable reading is obtained.

8.3 The following table summarizes the calibration and standardization information of the pH meter:

QC Measures	Calibration Frequency	Acceptance Criteria	Correction Action	Decontamination Procedures
Field Duplicate, freq. of 10%	Beginning of each work day/freq. of 10% thereafter	Slope=90-102%	Re-calibrate/change buffers/replace KCL sol'n	Rinse thoroughly with DI water

## 9 Procedures for pH Measurement of Non-aqueous Samples (e.g., soil, sediment, etc.)

- 9.1 Upon sample collection, samples should be placed in clean, new, glass containers with Teflon-lined lids. These containers should be free of any chemical preservation solutions and refrigerated until analysis. Field measurements of pH should be collected as soon as possible after sample collection.
- 9.2 Weigh out 20 g of sample and place in a 50-ml beaker. Add 20 ml of reagent water, cover, and stir the suspension for at least 5 minutes.
- 9.3 Let the soil suspension stand until the fine material (i.e., silts and/or clays) settles out from the suspension.
- 9.4 With the electrode secured in the clamps of the electrode holder, lower the electrode until the sensing bulb at the base of the electrode is within the clear supernatant solution. Make sure that the filling hole of the electrode is uncovered during use to allow for uniform flow of filling solution. NOTE: If the supernatant contains multiple phases, decant the oily phase and collect readings from the aqueous phase.
- 9.5 When the meter senses that the reading is stable, STABLE or READY will appear on the meter display. Record the pH measurement on the appropriate sample data form.
- 9.6 Decontaminate the electrode between samples by thoroughly rinsing the electrode with reagent water. A detergent rinse may also be added to this procedure, if necessary. If the supernatant contained multiple phases, the electrode should be decontaminated as described in Section 4.2.

## 10 Procedures for pH Measurement of Aqueous Samples

- 10.1 When collecting pH data of aqueous samples, care should be taken to eliminate or minimize the exposure of the sample to air prior to measurement. Sample collection procedures should be designed to minimize sample agitation, as well. If possible, pH readings should be collected as the sample is slowly pumped through a closed system, such as a flow-through cell. If a closed system is not available and the sampling location does not allow for the immersion of the electrode into a constantly flowing sample stream, samples should be placed in clean, new, glass containers

with Teflon-lined lids. These containers should be free of any chemical preservation solutions and refrigerated until analysis. Field measurements of pH should be collected as soon as possible after sample collection.

- 10.2 Place the sample in a clean glass beaker using a sufficient volume to cover the sensing bulb at the base of the electrode and allowing for adequate clearance for the magnetic stirring bar. If field measurements are taken without using a magnetic stirring bar, the electrode may be immersed to an adequate depth and moved in a manner to ensure sufficient sample movement across the sensing bulb as indicated by drift-free readings ( $< 0.1$  pH units).
- 10.3 When the meter senses that the reading is stable, STABLE or READY will appear on the meter display. Record the pH measurement on the appropriate sample data form.
- 10.4 Decontaminate the electrode between samples by thoroughly rinsing the electrode with reagent water. A detergent rinse may also be added to this procedure, if necessary.

## 11 Calculations

If the meter/electrode system utilized does not allow for temperature compensation and a sample temperature differs by more than  $2^{\circ}$  C from the buffer solutions used during calibration, the measured pH value of the sample must be corrected. This temperature difference and adjustment to the measured pH value must be documented on the appropriate sample data form.

## Applicable Forms

Field pH Meter Calibration Sheet

Surface Water Sampling Field Data Sheet

## Field pH Meter Calibration Sheet

[illegible]

**ELM** CONSULTING, L.L.C.  
 600 Hart Road, Suite 130  
 Barrington, Illinois 60010

### Surface Water Sampling Field Data Sheet

Project Description		Field Team Leader	
Project No.	Date	Time	
Sampling Personnel			
Sample ID			
Description of Sample Location & Observations			
Sunny <input type="checkbox"/>	Partly Sunny <input type="checkbox"/>	Cloudy <input type="checkbox"/>	Raining <input type="checkbox"/>
Calm <input type="checkbox"/>	Slightly Windy <input type="checkbox"/>	Windy <input type="checkbox"/>	Gusting Winds <input type="checkbox"/>
Ambient Air Temperature (°F):		Flow:	
Specific conductance (µmhos)		Water temperature (°C)	
pH		Dissolved oxygen (mg/L)	
Water samples collected (check)		Redox:	
<input type="checkbox"/>	volatile organic compounds	<input type="checkbox"/>	volatile organic compounds
<input type="checkbox"/>	semi-volatile organic compounds	<input type="checkbox"/>	semi-volatile organic compounds
<input type="checkbox"/>	priority pollutant pesticides	<input type="checkbox"/>	polychlorinated biphenyls
<input type="checkbox"/>	total organic carbon	<input type="checkbox"/>	Other _____
<input type="checkbox"/>	particle size distribution	<input type="checkbox"/>	Other _____
Comments			



## **Standard Operating Procedure (#99-0034-SOP-11) for the Collection of Electrolytic Conductance (EC) Data in Freshwater Ecosystems**

### **1 Scope & Summary**

This standard operating procedure (SOP) outlines the procedures for collecting electrolytic conductance (EC) data in the field from aqueous samples. This SOP is to be utilized to collect EC data in freshwater ecosystems and is specifically designed for the Orion Conductivity Meter (Models 105 and 115).

### **2 Reference Documents**

Orion Research, Inc., 1996. Instruction Manual for Models 105 and 115 Conductivity Meters.

Orion Research, Inc., 1996. Instruction Sheet for Conductivity Cells.

U.S. EPA, 1996. "Method 9050A - Specific Conductance." Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, Third Edition, Revision 1.

### **3 Significance and Use**

The data generated by these guidelines are considered Level II or screening data. While these data are scientifically defensible and can be used to aid in the decision-making process in the field, they may not withstand legal scrutiny in court proceedings.

### **4 Potential Interferences**

- 4.1 Platinum electrodes can degrade and cause erratic results. When this happens, as evidenced by erratic results or flaking off of the platinum black, the electrode should be replatinized. NOTE: Some electrodes are manufactured so that they cannot be replatinized. If these probes begin producing erratic results, replacement of the probe may be the only option. Contact the manufacturer for technical assistance.
- 4.2 Coatings of oily material or particulate matter can impair the response of the conductivity cell. These coatings can usually be removed by gentle wiping or detergent washing, followed by rinsing with deionized water. An additional rinsing with ethanol or acetone may be necessary to remove any remaining film. If the cell has received a coating of lime or hydroxide from samples, the cell may be soaked in 10% acetic or hydrochloric acid solution. If contaminants cannot be removed by the above cleaning methods, concentrated acid (such as nitric or acetic) may be used sparingly. However, cleaning may cause a slight shift in the cell constant. The cell constant must be determined before additional measurements are made.
- 4.3 Significant errors may result if the effects of temperature are ignored. For best results, use a temperature compensated conductivity cell, a separate ATC probe, or manual temperature compensation with the actual sample temperature entered in the meter.
- 4.4 The conductivity meter should be calibrated as directed by the instruction manual. If the meter is not properly calibrated prior to use, incorrect readings will be collected in the field.

### **5 Apparatus and Materials**

- conductivity meter and probe with means for temperature compensation;
- conductivity standard of known value;
- reagent-grade water;
- beakers.

## 6 Hazards & Precautions

- 6.1 Samples might contain potentially toxic materials, and thus should be treated with caution to minimize exposure to workers. Gloves are recommended.
- 6.2 The project Health and Safety Plan must be reviewed to identify further hazards, precautions and safety procedures.

## 7 Calibration

- 7.1 The conductivity meter/cell system must be calibrated at least once per day according to manufacturer specifications. The conductivity standard selected for calibration should approximate the maximum values expected from the samples. Thoroughly rinse the cell with reagent water prior to measuring the standard and following calibration procedures. All information regarding the calibration of the meter/electrode system (e.g., date, time, standard used, initials of field personnel, and final cell constant reading) must be documented on appropriate field equipment calibration forms. Calibration should be verified at least once per day, as well. This verification must be documented on appropriate field equipment calibration forms and/or in the field logbook.
- 7.2 A calibration check should be performed once for every 10 investigative readings collected (or 10%). To perform a calibration check, follow the specifications outlined in the instructional manual. Calibration solution is provided by the manufacturer.
- 7.3 The following table summarizes the calibration and standardization information of the conductivity meter:

QC Measures	Calibration Frequency	Acceptance Criteria	Correction Action	Decontamination Procedures
Field Duplicate, freq. of 10%	Beginning of each work day/freq. of 10% thereafter	Criteria hard-wired into system; "E-22" error message	Adjust cell constant; clean conductivity cell; return to factory	Rinse thoroughly with DI water

## 8 Procedures for Conductivity Measurement of Aqueous Samples

- 8.1 When collecting conductivity data of aqueous samples, care should be taken to eliminate or minimize the exposure of the sample to air prior to measurement. Sample collection procedures should be designed to minimize sample agitation, as well. If possible, conductivity readings should be collected as the sample is slowly pumped through a closed system, such as a flow-through cell. If a closed system is not available and the sampling location does not allow for the immersion of the cell into a constantly flowing sample stream, samples should be placed in clean, new, glass containers with Teflon-lined lids. These containers should be free of any chemical preservation solutions and refrigerated until analysis. Field measurements of conductivity should be collected as soon as possible after sample collection.
- 8.2 Place the sample in a clean glass beaker using a sufficient volume to cover the cell. Slightly agitate the cell to remove any air bubbles.

- 8.3 When the meter senses that the reading is stable, STABLE or READY will appear on the meter display. Record the conductivity measurement on the appropriate sample data form.
- 8.4 Decontaminate the cell between samples by thoroughly rinsing the electrode with reagent water. If a rinsing of reagent water is not sufficient to decontaminate the cell, follow the procedures described in Section 4.2.

***Applicable Forms***

Field Conductivity Meter Calibration Sheet

Surface Water Sampling Field Data Sheet



**ELM** CONSULTING, L.L.C.  
 600 Hart Road, Suite 130  
 Barrington, Illinois 60010

### Surface Water Sampling Field Data Sheet

Project Description		Field Team Leader	
Project No.	Date	Time	
Sampling Personnel			
Sample ID			
Description of Sample Location & Observations			
Sunny <input type="checkbox"/>	Partly Sunny <input type="checkbox"/>	Cloudy <input type="checkbox"/>	Raining <input type="checkbox"/>
Calm <input type="checkbox"/>	Slightly Windy <input type="checkbox"/>	Windy <input type="checkbox"/>	Gusting Winds <input type="checkbox"/>
Ambient Air Temperature (°F):		Flow:	
Specific conductance (µmhos)		Water temperature (°C)	
pH		Dissolved oxygen (mg/L)	
Water samples collected (check)		Redox:	
<input type="checkbox"/>	volatile organic compounds	<input type="checkbox"/>	volatile organic compounds
<input type="checkbox"/>	semi-volatile organic compounds	<input type="checkbox"/>	semi-volatile organic compounds
<input type="checkbox"/>	priority pollutant pesticides	<input type="checkbox"/>	polychlorinated biphenyls
<input type="checkbox"/>	total organic carbon	<input type="checkbox"/>	Other _____
<input type="checkbox"/>	particle size distribution	<input type="checkbox"/>	Other _____
Comments			



**Standard Operating Procedure (#99-0034-SOP-12) for Collecting Surface Soil Samples in the Vicinity of the Slag Pile Storage Area at the Doe Run Lead Smelter-Herculaneum, Missouri**

**1. Scope & Summary**

This standard operating procedure (SOP) outlines techniques for collecting surface soil samples (0-3 inches) in the vicinity of the Slag Pile Storage Area at the Doe Run Lead Smelter in Herculaneum, Missouri. The samples are described as "grab" samples, because they represent a discrete aliquot taken from one specific sampling location at a specific point in time. Soil samples are collected using a disposable plastic scoop sampler. Soil is placed into laboratory-certified pre-cleaned and pre-labeled jars with minimum headspace and packed in ice (in coolers) during transportation to the laboratory.

**2 Reference Documents**

ASTM (1997) *ASTM Standards on Environmental Sampling*, 2<sup>nd</sup> ed. W. Conshohocken, PA.

Cox, Doyle B. (2000) *Hazardous Materials Management - Desk Reference Guide*. Academy of Hazardous Materials Managers, McGraw Hill, Inc.

USEPA (1987) *A compendium of Superfund Field Operations Methods*. EPA/540/P-87/001. U. S. Environmental Protection Agency.

Soil Science Society of America (1985) *Water Potential Relations in Soil Microbiology*, SSSA Special Publication No. 9, Madison, WI.

**3. Significance and Use**

The techniques outlined in this SOP are described specifically for collecting surface soils related to the Slag Pile Investigation at the Doe Run Lead Smelter in Herculaneum, Missouri (ADMINISTRATIVE ORDER ON CONSENT - Docket No. VII-99-date pending). Specific personal protective and sampling equipment is utilized during the collection of soils for this investigation.

The samples collected by this method are suitable for chemical characterization. Quantitation limits are limited to those outlined in the U.S. EPA, Office of Solid Waste SW-846 Test Methods for Evaluating Solid Wastes. The protocol described herein is not an "ultraclean" sampling protocol requiring "clean-hands dirty-hands" techniques. Rather, the sampling method is typical to that of the environmental industry where disposable, single-use, non-talc, PVC gloves are worn during sampling activities only. The analytical results from grab samples collected using this method should provide a good representation of the concentration of contaminants present at the point and time the sample was collected. The results will be used to evaluate chemical concentrations in the soil at the sampling locations.

**4. Potential Interferences**

There are numerous routes by which samples may become contaminated. Potential sources of inorganic contamination during sampling include metallic or metal-containing sampling equipment, containers, labware (e.g. talc gloves that contain high levels of zinc), reagents, and deionized water, improperly cleaned and stored equipment, labware, and reagents; and

SOP for Collecting Surface Soil Samples in the Vicinity of the Slag Pile Storage Area at the Doe Run Lead Smelter-Herculaneum, Missouri

Revision 1.0, 08-Feb-01

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atmospheric inputs such as dirt and dust from automobile exhaust, cigarette smoke, nearby roads, bridges, wires, and poles.

- 4.1 The soil surface may not be homogeneous. This lack of homogeneity may result in sampling and analytical bias that results from ease of sample collection in the field as well as aliquot acquisition in the lab. Therefore, efforts should be made to collect representative soil from the sample location that minimizes the occurrence of large objects (sticks, stones, etc.) that may influence the results of the analysis.
- 4.2 Local geography may influence the evaluation of soil within a given area. The aspect of a slope or relative position of a slope to a potential source of contamination may influence the concentration of the contaminant in the soil. Therefore, similar geographical features were identified for soil sampling.
- 4.3 Differences in soil moisture content may bias the results of contaminant concentrations within a given geographical area as well as on a micro-scale at a sample location. Soil moisture content may be a result of the physical movement of water through or over soil, and is known to play an important role in the dynamics of soil microbiology. As a result, concentrations of contaminants observed in soil may be an artifact of leaching, deposition and/or microbial activity. Therefore, an attempt is made to collect soil with similar water content within a selected geographical area and local sampling location.
- 4.4 To ensure that the sample vessel and sampling equipment are not contributing to cross-contamination, the appropriate composition of the vessel and equipment is required depending on what analysis is to be conducted. For example, soil that is to be analyzed for organics should only be collected with metallic (non-plastic) scoops/trowels and put into sample vessels made of glass. Conversely, soil that is to be analyzed for inorganics should only be collected with plastic (non-metallic) scoops/trowels and put into sample vessels made of plastic.

## **5. Apparatus**

- 5.1 The hand-held, disposable plastic sample scoop is contained within a plastic wrapper, so that it does not contact anything other than the matrix to be sampled.
- 5.2 Disposable, non-talc, PVC gloves are used by the sample team, to minimize the occurrence of cross contamination between sample points or between materials contacted by the sampling team that are not intended to come in contact with the sample.

## **6. Materials**

- Sample scoop/trowel (metallic or plastic depending on which analysis is conducted-Section 4.4)
- Sample containers with lids of type consistent with the requested analytical methods
- Sample labels
- Waterproof marking pens/pencils

- Disposable, non-talc, PVC gloves
- Cooler
- Sample data forms/clip board
- Camera and film
- personal safety gear
- compass

## **7. Hazards & Precautions**

- 7.1 Collecting samples in cold weather, especially around cold water bodies, carries the risk of hypothermia, and collecting samples in extremely hot and humid weather carries the risk of dehydration and heat stroke. Sampling team members should wear adequate clothing for protection in cold weather and should carry an adequate supply of water or other liquids for protection against dehydration in hot weather.
- 7.2 A project Health and Safety Plan will be written to address all potential and inherent health and safety issues surrounding the sampling of soil.
- 7.3 Field-collected soil might contain potentially toxic materials, and thus should be treated with caution to minimize exposure to workers. Appropriate clothing and gloves are recommended.

## **8. Sample Preparation**

- 8.1 Sample locations may be adjusted on-site as deemed necessary by physical obstructions, or other factors. A pre-sampling site inspection should be conducted to evaluate for sampling limitations of desired locations.
- 8.2 Appropriate sample containers will be obtained from the analytical laboratory.
- 8.3 The Field Team Leader will read the Quality Assurance Project Plan before field sampling procedures are undertaken to understand how many, and what type of QA/QC samples are required.
- 8.4 The Field Team Leader must read the Health and Safety Plan prior to sampling to review applicable safety requirements.

## **9. Preparation of Apparatus**

- 9.1 The field equipment should be assembled into the equipment cooler prior to departure.

## **10. Calibration & Standardization**

- 10.1 No equipment calibration is required for sampling of soil.

## **11. Procedures**

- 11.1 Site Selection – See Work Plan.

- 11.1.1 The specific sample location will be selected based upon similar drainage features and soil moisture content.

- 11.2 Sampler and assistant will don disposable, non-talc, PVC gloves prior to sample collection.
- 11.3 Assistant will label sample jars and the sampler will prepare sample equipment to collect sample from sample location. As mentioned in Section 4.4, the appropriate sample vessel and equipment is crucial to prevent cross-contamination.
- 11.4 Prepare sample location by removing overlying debris (leaves, sticks, stones) to expose underlying soil. The samplers will not sample an area that has been tracked-upon.
- 11.5 Sampler will unearth soil to a depth not to exceed 3 inches with plastic scoop and place soil sample into sample jar. The sampler will immediately place lid upon jar, and wipe excess material from outside of jar. Sample jar will then be placed into plastic bubble-wrap bag and placed into cooler containing ice.
- 11.6 Samples will be recorded on a chain-of-custody form and placed into the cooler containing the samples, so that the chain-of custody form accompanies the samples for which it is prepared.
- 11.7 Assistant will take photographs of the sample location, and photographs in a direction both up-slope and down-slope from the sample location. Location of sample will be noted on map and verbally described on field data sheet. Photographs of sample consistency will also be documented.
- 11.8 Assistant will record compass readings between sample points and other significant features on field data sheets.
- 11.9 Sample scoop and gloves will be disposed of in a trash bag. No other decontamination will be necessary.
- 11.10 Sample cooler is packed and shipped according to laboratory and shipper protocols.

**12. Calculations** Not Applicable

**13. Applicable Forms**

Field Data Form for Surface Soil Sampling

Drilling Log

Audit Checklist for Slag Sampling

Audit Finding Report

Photograph Log

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 600 Hart Road, Suite 130  
 Barrington, IL 60010

### Surface Soil Sampling Field Data Sheet

Project Description		Field Team Leader	
Project No.	Date	Time	
Sampling Personnel			
Sample ID			
Description of Sample Location & Observations			
Sunny <input type="checkbox"/>	Partly Sunny <input type="checkbox"/>	Cloudy <input type="checkbox"/>	Raining <input type="checkbox"/>
Calm <input type="checkbox"/>	Slightly Windy <input type="checkbox"/>	Windy <input type="checkbox"/>	Gusting Winds <input type="checkbox"/>
Ambient Air Temperature (°F): _____			
Specific conductance (µmhos) (if applicable)		Water temperature (°C) (if applicable)	
pH (if applicable)		Dissolved oxygen (mg/L) (if applicable)	
Surface soil samples collected (check)			
priority pollutant metals		Individual Metal _____	
Skinner List of Inorganics		Individual Metal _____	
total organic carbon		Individual Metal _____	
Particle Size Distribution		Other _____	
Individual Metal _____		Other _____	
Comments			

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 600 Hart Road, Suite 130  
 Barrington, Illinois 60010

### Audit Checklist for Slag Sampling

Project Description	Field Team Leader			
Project No.	Audit Date			
Sampling personnel	Audit No.			

Audit Question	S	U	N/A	comments
Were all personnel briefed on their assignment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Did the crew have all the forms and maps, equipment and materials necessary to complete the assigned tasks?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were the sampling locations correctly identified on the forms?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were the field meters properly calibrated?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were samples collected according to the procedure and all potential interferences addressed before sampling?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Was the depth of the sediment samples consistent?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were sample locations properly marked for the survey crew?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were the sampling equipment and meter probes properly cleaned between sample locations?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were all sample containers properly labeled?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were all sample containers properly filled (e.g. no head space)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Were all samples properly packed for shipping?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
packed in ice?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
custody seals in appropriate places?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Did personnel adhere to the safety procedures?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Auditor Signature: \_\_\_\_\_

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 600 Hart Road, Suite 130  
 Barrington, Illinois 60010

### Audit Finding Report

Project No. _____	Task No. _____	Audit No. _____	Audit Date _____
Individual(s) contacted _____		Auditor Signature _____	
Requirements _____			
Findings _____			
Recommended Corrective Action _____			
Scheduled Response Date _____		Responsible for Corrective Action _____	
<i>Corrective Action Taken</i> _____			
<i>Date</i> _____	<i>Submitted by</i> _____	<i>Management Approval</i> _____	
Date Response Received _____		Response Acceptable?	Yes    No
Reason for Rejection _____			
Verification _____			
Date Verified _____		Auditor Signature _____	

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 Barrington, Illinois 60010

### Photograph Log

Project Description		Field Team Leader	
Project No.	Task No.	Photos By	
Date(s)		Location	
Film Type		Roll/Disk #	of
Frame	Subject/Sample ID	Frame	Subject/Sample ID
1		19	
2		20	
3		21	
4		22	
5		23	
6		24	
7		25	
8		26	
9		27	
10		28	
11		29	
12		30	
13		31	
14		32	
15		33	
16		34	
17		35	
18		36	

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**DRILLING LOG**

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GEOLOGIST						BORING NUMBER
FACILITY / PROJECT						ELEVATION
DATE / TIME DRILLED						X,Y COORDINATES
DRILLING METHOD						TOTAL DEPTH
DRILLING COMPANY						DEPTH TO WATER
DEPTH (feet)	RECOVERY / INTERVAL (feet)	SAMPLE / MATRIX / TIME / ANALYSIS	MOISTURE CONTENT / DEPTH TO WATER	PID/ FID (ppm)	INTERFACE	DESCRIPTION AND REMARKS
1						
2						
3						
4						
5						
6						
7						
8						
9						
0						



## **Standard Operating Procedure (#99-0034-SOP-13) for the Collection of Redox Potential (ORP) Data in Freshwater Ecosystems**

### **1 Scope & Summary**

This standard operating procedure (SOP) outlines the procedures for collecting redox potential (ORP) data in the field from aqueous samples in freshwater ecosystems.

### **2 Reference Document**

Fisher Scientific, 1998. Instruction Manual for Accumet AP Series Handheld pH/mV/Ion Meter.

Orion Research, Inc., 1997. Instruction Manual for Platinum Redox Electrodes.

### **3 Significance and Use**

- 3.1 The data generated by these guidelines are considered Level II or screening data. While these data are scientifically defensible and can be used to aid in the decision-making process in the field, they may not withstand legal scrutiny in court proceedings.
- 3.2 The protocols outlined in this SOP are to be followed using only the Accumet AP Series Handheld pH/mV/Ion Meter with Platinum Redox Electrodes.

### **4 Potential Interferences**

- 4.1 Significant sample flow across the probe can cause erratic results due to the effects of excessive ion streaming. This can be remedied by a reduction in sample flow rate.
- 4.2 The electrode filling solution should be selected to best match the ionic strength of the sample solution to minimize junction potentials. The level of the filling solution should always be at least one inch above the level of the sample.
- 4.3 Exposure of the sample to air and/or excessive turbulence may significantly decrease the accuracy of the reading.

### **5 Apparatus and Materials**

- pH meter with a millivolt (mV) mode and a platinum redox electrode. NOTE: Electrodes with a ceramic frit junction resistant to organic solvents are preferred;
- reagent-grade water

### **6 Hazards & Precautions**

- 6.1 Samples might contain potentially toxic materials, and thus should be treated with caution to minimize exposure to workers. Gloves are recommended.
- 6.2 The project Health and Safety Plan must be reviewed to identify further hazards, precautions and safety procedures.

### **7 Calibration and Standardization**

- 7.1 Redox probes are calibrated by the manufacturer; therefore, field calibration is not necessary. However, the calibration of the probe can be verified using potassium

ferrocyanide or iodine solutions. Refer to the probe instruction manual or contact the manufacturer for technical support. If a verification of calibration is performed in the field, the results must be documented on the appropriate field equipment calibration forms and/or in the field logbook.

- 7.2 The following table summarizes the calibration and standardization information of the ORP meter:

QC Measures	Calibration Frequency	Acceptance Criteria	Correction Action	Decontamination Procedures
Field Duplicate, freq. of 10%	Not Applicable- Factory calibrated	Suspect data	Clean electrode and replace electrode solution; return to factory	Rinse thoroughly with DI water

## 8 Procedures for the Collection of Redox Potential Data

- 8.1 When collecting redox potential data, care should be taken to eliminate the exposure of the sample to air prior to measurement. Sample collection procedures should be designed to minimize sample agitation, as well. Redox potential readings should be collected as the sample is slowly pumped through a closed system, such as a flow-through cell. If a closed system is not available, the accuracy of the data may be significantly reduced.
- 8.2 After immersion of the probe into the sample, make sure that sufficient sample flow is present during measurement. When the meter senses that the reading is stable, STABLE or READY will appear on the meter display. Record the measurement on the appropriate sample data form.
- 8.3 Decontaminate the probe between samples by thoroughly rinsing the electrode with reagent water.

### Applicable Forms

Surface Water Sampling Field Data Sheet

**ELM** CONSULTING, L.L.C.  
 600 Hart Road, Suite 130  
 Barrington, Illinois 60010

### Surface Water Sampling Field Data Sheet

Project Description		Field Team Leader	
Project No.	Date	Time	
Sampling Personnel			
Sample ID			
Description of Sample Location & Observations			
Sunny <input type="checkbox"/>	Partly Sunny <input type="checkbox"/>	Cloudy <input type="checkbox"/>	Raining <input type="checkbox"/>
Calm <input type="checkbox"/>	Slightly Windy <input type="checkbox"/>	Windy <input type="checkbox"/>	Gusting Winds <input type="checkbox"/>
Ambient Air Temperature (°F):		Flow:	
Specific conductance (µmhos)		Water temperature (°C)	
pH		Dissolved oxygen (mg/L)	
Water samples collected (check)		Redox:	
<input type="checkbox"/>	volatile organic compounds	<input type="checkbox"/>	volatile organic compounds
<input type="checkbox"/>	semi-volatile organic compounds	<input type="checkbox"/>	semi-volatile organic compounds
<input type="checkbox"/>	priority pollutant pesticides	<input type="checkbox"/>	polychlorinated biphenyls
<input type="checkbox"/>	total organic carbon	<input type="checkbox"/>	Other _____
<input type="checkbox"/>	particle size distribution	<input type="checkbox"/>	Other _____
Comments			

## **Standard Operating Procedure (#99-0034-SOP-14) for the Qualitative Floristic Community Survey**

### **1. Scope & Summary**

This standard operating procedure (SOP) outlines techniques for performing a Qualitative Floristic Community Survey in terrestrial and wet environments. This SOP is not intended to be utilized in environments that have standing water greater than 0.5 meters in depth.

### **2. Reference Documents**

Brower, J.E., J.H. Zar, and C.N. von Ende. 1998. Field and laboratory methods for general ecology. 4th Edition, McGraw-Hill Companies, Inc., New York.

Kent, M. and P. Coker. 1992. Vegetation description and analysis - a practical approach. Belhaven Press, London.

### **3. Significance and Use**

The use of a qualitative floristic survey at a particular site provides the botanist the opportunity to determine whether threatened and endangered species are present. It is important that such a survey be conducted to determine if sensitive areas are present in an area where potential remediation may occur. Results from the survey may be given to state agencies to be included in threatened and endangered species databases and map sensitive habitats.

### **4. Potential Interferences**

- 4.1. An expert in plant taxonomy and plant identification must be utilized in the field during any type of floristic survey. When errors are made in plant identification, interpretations of the data will be invalid and no legitimate conclusions as to the floristic community can be made. The botanist should have specific expertise in state and federally-listed plant species as well as indicator species information and habitat preference.
- 4.2. Floristic community surveys should be conducted in the spring and summer seasons. Identification of plants is much easier when flowering parts are visible. Some plants can only be identified when certain morphological characteristics are visible in the spring and summer months.

### **5. Materials**

- Qualitative Floristic Survey-Field Data Sheet;
- Threatened and Endangered Plant Species Discovery-Field Data Sheet;
- "Rite-In-The-Rain" paper;
- "Rite-In-The-Rain" Notebooks;
- Compasses
- Reflectors;
- Field guides;
- Tree markers;
- Signs indicating sensitive natural habitat;
- Pencils/waterproof pens;
- Sunscreen;
- Insect repellent;
- Pin flags;
- Flagging;

- Taxonomic keys;
- Clipboard;
- Digital camera/disks or camera/film;
- Hand magnifying lens;
- Maps and aerial photos;
- First Aid Kit.

## **6. Hazards & Precautions**

- 6.1. The investigator should avoid performing floristic community surveys when inclement weather conditions are present such as thunder and lightning, strong winds, and heavy rain. Dangerous weather conditions increase the risk of electrocution, falling tree limbs and slip, trip and falls hazards.

## **7. Field Procedures**

- 7.1. Determine the study area where the survey should be conducted. Refer to the workplan of the particular project to find the objectives of the survey.
- 7.2. The botanist should become familiar with the ecology and natural resources of the study area through site observation and aerial photography. Relevant background and historic information of the study area should be obtained.
- 7.3. The trained botanist walks all accessible areas of the study area and observes all vegetative communities (canopy, subcanopy, shrub, herb, vine, etc.).
- 7.4. The botanist completes the "Qualitative Florist Survey - Field Data Sheet". The botanist concentrates on the presence or absence of suitable habitat for threatened and endangered species and looks for individual threatened and endangered plants.
- 7.5. If no threatened and endangered plants are observed, the botanists indicates the results on the field data sheet and informs the proper state agency. If threatened and endangered plants are discovered, complete the "Threatened and Endangered Plant Species Discovery - Field Data Sheet".
- 7.6. The botanist should photograph the area where sensitive plants are present. Additionally, the area of the sensitive plants should be demarcated with flagging and signs should be posted to indicate sensitive habitat.
- 7.7. This botanist should immediately notify the proper state agency to that protection procedures can be implemented by the state.

## **8. Calculations**

No calculations necessary for this SOP.

## **9. Applicable Forms**

Qualitative Floristic Survey Field Data Sheet

Threatened and Endangered Plant Species Discovery - Field Data Sheet

Photograph Log

**THREATENED AND ENDANGERED PLANT SPECIES DISCOVERY – FIELD DATA SHEET**

Project Name: \_\_\_\_\_ ELM Project #: \_\_\_\_\_

Investigator(s): \_\_\_\_\_ Date/Time: \_\_\_\_\_

On-site or Off-site (circle one)      Habitat Type where Listed Species was Observed: \_\_\_\_\_

**State-Listed Plant Species Observed:****Number of Individuals (one, sparse patches, dense stand, etc):****Detailed Location where State-Listed Plant Species was Observed:****General Site Characteristics and Ecology of Area where State-Listed Plant Species was Observed:****Actions Taken to Demarcate Area where State-Listed Plant Species was Observed:****Marker Number:****Notes/Comments:**

**QUALITATIVE FLORISTIC SURVEY - FIELD DATA SHEET**

Project Name: \_\_\_\_\_ ELM Project #: \_\_\_\_\_

Date: \_\_\_\_\_ Investigator(s): \_\_\_\_\_ On-site or Off-site (circle one)  
Time: \_\_\_\_\_General Location of Area Being Surveyed: \_\_\_\_\_  
\_\_\_\_\_

Habitat Type of Area Being Surveyed: \_\_\_\_\_

General Site Characteristics and Ecology of Area Being Surveyed: \_\_\_\_\_  
\_\_\_\_\_

<b>DOMINANT SPECIES PRESENT (six letter code)</b>			

Suitable Habitat for Threatened and Endangered Species Observed:

YES: \_\_\_\_\_ NO: \_\_\_\_\_ (If YES, give description):

Indicator Species Observed:

YES: \_\_\_\_\_ NO: \_\_\_\_\_ (If YES, give description):

Threatened and Endangered Species Observed:

YES: \_\_\_\_\_ (Fill out Threatened and Endangered Species Field Data Sheet - Form # \_\_\_\_\_)

NO: \_\_\_\_\_

Notes/Comments: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**APPENDIX B**

**LETTER FROM THE MISSOURI DEPARTMENT OF  
CONSERVATION DESCRIBING NATURAL RESOURCES  
INFORMATION FOR THE HERCULANEUM AREA**



# MISSOURI DEPARTMENT OF CONSERVATION

## Headquarters

2901 West Truman Boulevard, P.O. Box 180, Jefferson City, Missouri 65102-0180  
Telephone: 573-751-4115 ♦ Missouri Relay Center: 1-800-735-2966 (TDD)

JERRY M. CONLEY, Director

*Happy  
Holidays*

December 15, 2000

Mr. Jeff Stringer  
ELM Consulting  
600 Hart Road, Suite 130  
Barrington, IL 60010

Re: Natural Resources Information for the Herculaneum Area

Dear Mr. Stringer:

Thank you for your letter of November 13, 2000, regarding species of conservation concern within the Herculaneum area and Joachim watershed.

Review of our records show that public lands, species of conservation concern or sensitive communities are known to occur within the Joachim watershed. Please refer to the enclosed Heritage Database report for details. This report reflects information we currently have in our database and it should not be regarded as a definitive statement as to the presence or absence of species of conservation concern or high-quality natural communities. We provide this information for planning purposes only. Additional on-site inspections may be needed to verify the presence or absence of such species or communities.

Joachim Creek, because of its high biologic diversity, has been identified by this agency as a priority stream and will receive administrative emphasis by St. Louis District staff.

This letter and report address threatened and endangered species, fish surveys and inventories, and macroinvertebrate surveys and inventories as requested in your letter. Additional natural resources information you requested should be obtained from other sources. Further information requests concerning this project should be directed to Ms. Karen Bataille who represents this agency as a trustee for natural resources damage assessment. She can be reached at our Conservation Research Center, 1110 S. College Ave., Columbia, MO, 65201, or by phone at (573) 882-9880 ext. 3215.

COMMISSION

ANITA B. GORMAN  
Kansas City

RANDY HERZOG  
St. Joseph

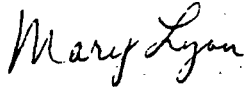
RONALD J. STITES  
Plattsburg

HOWARD L. WOOD  
Bonne Terre

Mr. Stringer  
December 15, 2000  
Page Two

Thank you for the opportunity to review and comment.

Sincerely,



MARY LYON  
POLICY ANALYST



KAREN BATAILLE  
ENVIRONMENTAL SERVICES BIOLOGIST

ML:bg

c: Jim Dwyer, USFWS  
Frances Klahr, DNR

Enclosure



ELM CONSULTING  
600 HART ROAD, SUITE 130  
BARRINGTON, IL 60010

## NATURAL RESOURCES INFORMATION - HERCULANEUM AREA AND JOACHIM WATERSHED

The following species and/or natural communities are known to occur on or in the vicinity of the project site:

<u>Scientific Name</u>	<u>Common Name</u>	<u>Federal Status</u>	<u>State Status</u>	<u>State Rank</u>	<u>Size/ Acres</u>	<u>Township/ Range</u>	<u>Sec.</u>	<u>Ownership</u>
DOLOMITE GLADE CLEMATIS FREMONTII	FREMONT'S LEATHER FLOWER			S3	11	041N005E 041N005E	27 27	PRIVATE PRIVATE

### Additional Information for planning purposes:

Overwintering bald eagles may occur in the project area, as they are common winter residents in big river habitats and major lakes where they feed on fish.

Pallid sturgeons are big river fish that may range widely in the Mississippi River and Missouri River system. Because the preferred habitat and range of the species are unknown, any project that modifies big river habitat or impacts water quality should consider the possible impact to pallid sturgeon populations.

The project area occurs near a region of karst geology. These areas are characterized by subterranean water movement. Features like caves, springs, and sinkholes are common. Cave fauna are influenced by water pollution and other changes to water quality. Every effort should be made to protect groundwater in the project area.

**FEDERAL STATUS** - The federal status is derived from the provisions of the federal Endangered Species Act, which is administered by the U.S. Fish and Wildlife Service. The Endangered Species Act provides federal protection for plants and animals listed as Endangered or Threatened. E = Endangered, T = Threatened, C = Candidate, PE = Proposed Endangered for Federal listing.

**STATE STATUS (E)** - The state status is determined by the Department of Conservation under constitutional authority. Rule 3CSR10-4.111 Endangered Species of the Wildlife Code of Missouri and certain state statutes apply to state Endangered species.

**STATE RANK** - A numeric rank of relative endangerment based primarily on the number of occurrences of the species within the state of Missouri. S1 = Critically imperiled in the state, S2 = Imperiled in the state, S3 = Rare and uncommon in the state.

Heron rookeries, eastern collared lizard populations, natural communities and geologic features are recognized as sensitive biological resources and may also appear on this report.

## **APPENDIX C**

### **ARMY CORPS OF ENGINEERS ROUTINE WETLAND DETERMINATION DATA FORMS DESCRIBING FOUR DATA POINTS IN THE SLAG INVESTIGATION AREA**

**DATA FORM**  
**ROUTINE WETLAND DETERMINATION**  
(1987 COE Wetlands Delineation Manual)

Project/Site: <u>Slag pile area, Site #1</u> Applicant/Owner: <u>Doc Run Company</u> Investigator: <u>Ward Lenz, Kathrine Kelley</u>	Date: <u>March 24, 1999</u> County: <u>Jefferson</u> State: <u>Missouri</u>
Do Normal Circumstances exist on the site? <input checked="" type="radio"/> Yes <input type="radio"/> No Is the site significantly disturbed (Atypical Situation)? Yes <input checked="" type="radio"/> No <input type="radio"/> Is the area a potential Problem Area? Yes <input checked="" type="radio"/> No <input type="radio"/> (If needed, explain on reverse.)	Community ID: <u>1</u> Transect ID: _____ Plot ID: <u>1</u> <u>Mapped as 1-1</u>

**VEGETATION**

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. <u>Ulmus americana</u>	<u>T</u>	<u>FACW-</u>	9. _____	_____	_____
2. <u>Acer saccharinum</u>	<u>T</u>	<u>FACW</u>	10. _____	_____	_____
3. <u>Carex spp.</u>	<u>H</u>	<u>?</u>	11. _____	_____	_____
4. _____	_____	_____	12. _____	_____	_____
5. _____	_____	_____	13. _____	_____	_____
6. _____	_____	_____	14. _____	_____	_____
7. _____	_____	_____	15. _____	_____	_____
8. _____	_____	_____	16. _____	_____	_____

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-): ≥ 66%

Remarks: \_\_\_\_\_

**HYDROLOGY**

<p>___ Recorded Data (Describe in Remarks):</p> <p style="margin-left: 20px;">___ Stream, Lake, or Tide Gauge</p> <p style="margin-left: 20px;">___ Aerial Photographs</p> <p style="margin-left: 20px;">___ Other</p> <p>___ No Recorded Data Available</p> <hr/> <p><b>Field Observations:</b></p> <p>Depth of Surface Water: _____ (in.)</p> <p>Depth to Free Water in Pit: _____ (in.)</p> <p>Depth to Saturated Soil: _____ (in.)</p>	<p><b>Wetland Hydrology Indicators:</b></p> <p><b>Primary Indicators:</b></p> <p>___ Inundated</p> <p>___ Saturated in Upper 12 Inches</p> <p>___ Water Marks</p> <p>___ Drift Lines</p> <p>___ Sediment Deposits</p> <p>___ Drainage Patterns in Wetlands</p> <p><b>Secondary Indicators (2 or more required):</b></p> <p><input checked="" type="checkbox"/> Oxidized Root Channels in Upper 12 Inches</p> <p><input checked="" type="checkbox"/> Water-Stained Leaves</p> <p><input checked="" type="checkbox"/> Local Soil Survey Data</p> <p><input checked="" type="checkbox"/> FAC-Neutral Test</p> <p>___ Other (Explain in Remarks): _____</p>
<p>Remarks: _____</p>	

**DATA FORM**  
**ROUTINE WETLAND DETERMINATION**  
 (1987 COE Wetlands Delineation Manual)

Project/Site: <u>Slag pile area, Site #1</u> Applicant/Owner: <u>Doe Run Company, Herculaneum, MO</u> Investigator: <u>Ward Lenz, Kathrine Kelley</u>	Date: <u>March 24, 1999</u> County: <u>Jefferson</u> State: <u>Missouri</u>
Do Normal Circumstances exist on the site? <input checked="" type="radio"/> Yes <input type="radio"/> No Is the site significantly disturbed (Atypical Situation)? <input type="radio"/> Yes <input checked="" type="radio"/> No Is the area a potential Problem Area? <input type="radio"/> Yes <input checked="" type="radio"/> No (If needed, explain on reverse.)	Community ID: <u>1</u> Transect ID: _____ Plot ID: <u>2</u> <u>Mapped as 1-2</u>

**VEGETATION**

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. <u>Ulmus americana</u>	<u>T</u>	<u>FACW-</u>	9. _____	_____	_____
2. <u>Carex spp.</u>	<u>H</u>	<u>?</u>	10. _____	_____	_____
3. <u>Acer saccharinum</u>	<u>T</u>	<u>FACW</u>	11. _____	_____	_____
4. <u>Apocynum cannabinum</u>	<u>S</u>	<u>FAC</u>	12. _____	_____	_____
5. <u>Salix nigra</u>	<u>T</u>	<u>OBL</u>	13. _____	_____	_____
6. _____	_____	_____	14. _____	_____	_____
7. _____	_____	_____	15. _____	_____	_____
8. _____	_____	_____	16. _____	_____	_____

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). ≥ 80 %

Remarks: \_\_\_\_\_

**HYDROLOGY**

<p> <input type="checkbox"/> Recorded Data (Describe in Remarks):  <input type="checkbox"/> Stream, Lake, or Tide Gauge  <input type="checkbox"/> Aerial Photographs  <input type="checkbox"/> Other  <input type="checkbox"/> No Recorded Data Available         </p> <hr/> <p>Field Observations:</p> <p>Depth of Surface Water: _____ (in.)</p> <p>Depth to Free Water in Pit: <u>6</u> (in.)</p> <p>Depth to Saturated Soil: _____ (in.)</p>	<p><b>Wetland Hydrology Indicators:</b></p> <p><b>Primary Indicators:</b></p> <p> <input type="checkbox"/> Inundated  <input checked="" type="checkbox"/> Saturated in Upper 12 Inches  <input type="checkbox"/> Water Marks  <input type="checkbox"/> Drift Lines  <input type="checkbox"/> Sediment Deposits  <input type="checkbox"/> Drainage Patterns in Wetlands         </p> <p><b>Secondary Indicators (2 or more required):</b></p> <p> <input checked="" type="checkbox"/> Oxidized Root Channels in Upper 12 Inches  <input checked="" type="checkbox"/> Water-Stained Leaves  <input checked="" type="checkbox"/> Local Soil Survey Data  <input checked="" type="checkbox"/> FAC-Neutral Test  <input type="checkbox"/> Other (Explain in Remarks)         </p>
<p>Remarks: _____</p>	

**DATA FORM**  
**ROUTINE WETLAND DETERMINATION**  
 (1987 COE Wetlands Delineation Manual)

Project/Site: <u>Slog pile area, site #1</u> Applicant/Owner: <u>Doe Run Company, Herculaneum, MO</u> Investigator: <u>Ward Lenz, Kathrine Kelley</u>	Date: <u>March 24, 1999</u> County: <u>Jefferson</u> State: <u>Missouri</u>
Do Normal Circumstances exist on the site? <span style="float: right;"><input checked="" type="radio"/> Yes <input type="radio"/> No</span> Is the site significantly disturbed (Atypical Situation)? <span style="float: right;"><input type="radio"/> Yes <input checked="" type="radio"/> No</span> Is the area a potential Problem Area? <span style="float: right;"><input type="radio"/> Yes <input checked="" type="radio"/> No</span> (If needed, explain on reverse.)	Community ID: <u>1</u> Transect ID: _____ Plot ID: <u>3</u> <u>Mapped as 1-3</u>

**VEGETATION**

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. <u>Carex Spp</u>	<u>H</u>	<u>?</u>	9. _____	_____	_____
2. <u>Fraxinus pennsylvanica</u>	<u>T</u>	<u>FACW</u>	10. _____	_____	_____
3. <u>Salix nigra</u>	<u>T</u>	<u>OBL</u>	11. _____	_____	_____
4. _____	_____	_____	12. _____	_____	_____
5. _____	_____	_____	13. _____	_____	_____
6. _____	_____	_____	14. _____	_____	_____
7. _____	_____	_____	15. _____	_____	_____
8. _____	_____	_____	16. _____	_____	_____

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-): ≥ 66%

Remarks: \_\_\_\_\_

**HYDROLOGY**

<p>___ Recorded Data (Describe in Remarks):</p> <p style="margin-left: 20px;">___ Stream, Lake, or Tide Gauge</p> <p style="margin-left: 20px;">___ Aerial Photographs</p> <p style="margin-left: 20px;">___ Other</p> <p>___ No Recorded Data Available</p> <hr/> <p>Field Observations:</p> <p>Depth of Surface Water: _____ (in.)</p> <p>Depth to Free Water in Pit: <u>6</u> (in.)</p> <p>Depth to Saturated Soil: _____ (in.)</p>	<p>Wetland Hydrology Indicators:</p> <p>Primary Indicators:</p> <p style="margin-left: 20px;"><input checked="" type="checkbox"/> Inundated</p> <p style="margin-left: 20px;"><input checked="" type="checkbox"/> Saturated in Upper 12 Inches</p> <p style="margin-left: 20px;">___ Water Marks</p> <p style="margin-left: 20px;">___ Drift Lines</p> <p style="margin-left: 20px;">___ Sediment Deposits</p> <p style="margin-left: 20px;">___ Drainage Patterns in Wetlands</p> <p>Secondary Indicators (2 or more required):</p> <p style="margin-left: 20px;"><input checked="" type="checkbox"/> Oxidized Root Channels in Upper 12 Inches</p> <p style="margin-left: 20px;">___ Water-Stained Leaves</p> <p style="margin-left: 20px;">___ Local Soil Survey Data</p> <p style="margin-left: 20px;"><input checked="" type="checkbox"/> FAC-Neutral Test</p> <p style="margin-left: 20px;">___ Other (Explain in Remarks)</p>
<p>Remarks: _____</p>	

**DATA FORM**  
**ROUTINE WETLAND DETERMINATION**  
(1987 COE Wetlands Delineation Manual)

Project/Site: <u>Proposed slag pile, Site #2</u> Applicant/Owner: <u>Doe Run Company, Herculaneum, MO</u> Investigator: <u>Ward Lenz, Kathrine Kelley</u>	Date: <u>March 24, 1999</u> County: <u>T Jefferson</u> State: <u>Missouri</u>
Do Normal Circumstances exist on the site? <input checked="" type="radio"/> Yes <input type="radio"/> No Is the site significantly disturbed (Atypical Situation)? Yes <input type="radio"/> No <input checked="" type="radio"/> Is the area a potential Problem Area? Yes <input type="radio"/> No <input checked="" type="radio"/> (If needed, explain on reverse.)	Community ID: <u>2</u> Transect ID: _____ Plot ID: <u>1</u> <u>Mapped as 2-1</u>

**VEGETATION**

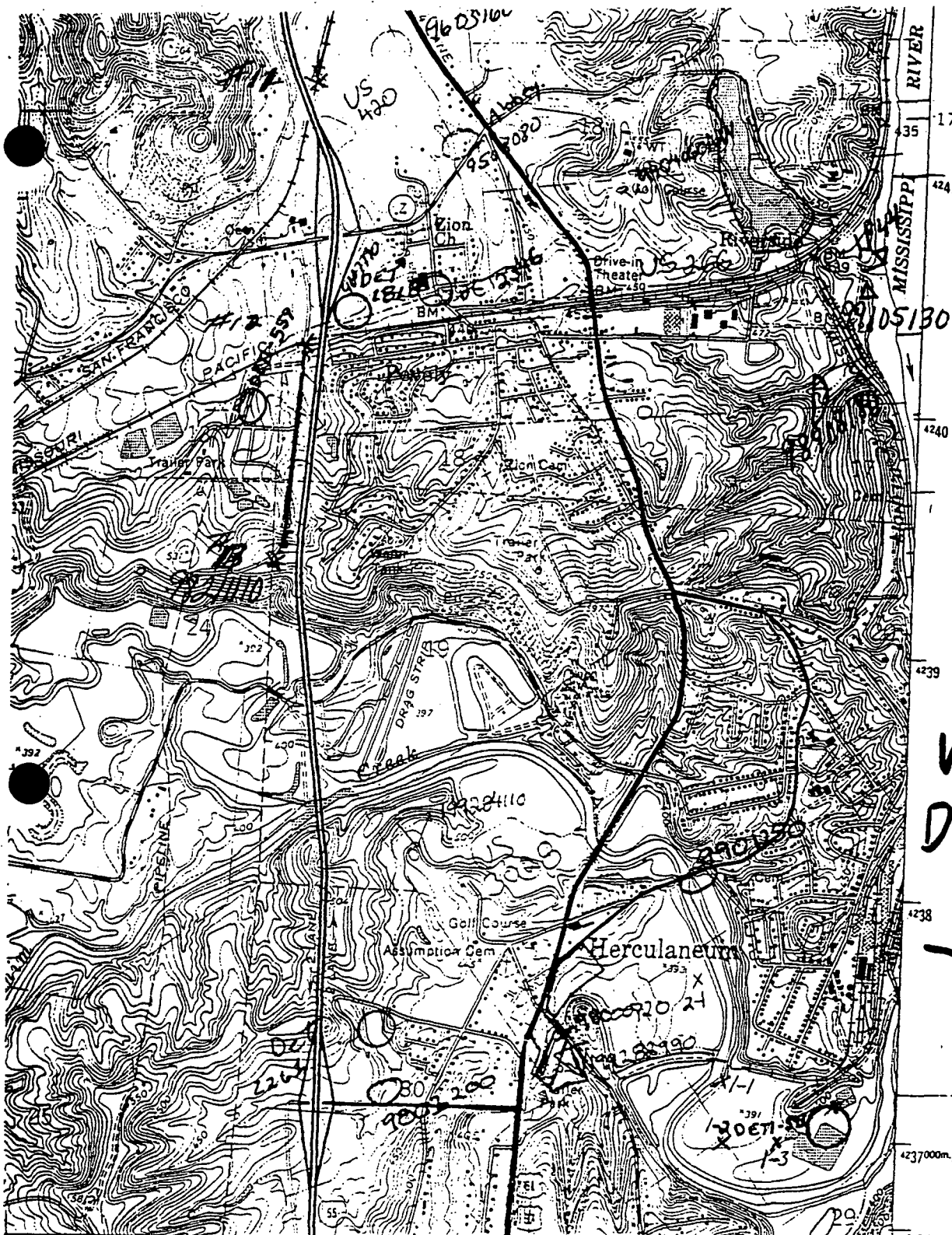
Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. <u>ACER Saccharinum</u>	<u>T</u>	<u>FACW</u>	9. _____	_____	_____
2. <u>ULMUS AMERICANA</u>	<u>T</u>	<u>FACW</u>	10. _____	_____	_____
3. <u>FRAXINUS pennsylvanica</u>	<u>T</u>	<u>FACW</u>	11. _____	_____	_____
4. _____	_____	_____	12. _____	_____	_____
5. _____	_____	_____	13. _____	_____	_____
6. _____	_____	_____	14. _____	_____	_____
7. _____	_____	_____	15. _____	_____	_____
8. _____	_____	_____	16. _____	_____	_____

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-): 100%

Remarks: \_\_\_\_\_

**HYDROLOGY**

<p>___ Recorded Data (Describe in Remarks):</p> <p>___ Stream, Lake, or Tide Gauge</p> <p>___ Aerial Photographs</p> <p>___ Other</p> <p>___ No Recorded Data Available</p> <hr/> <p>Field Observations:</p> <p>Depth of Surface Water: _____ (in.)</p> <p>Depth to Free Water in Pit: <u>7</u> (in.)</p> <p>Depth to Saturated Soil: _____ (in.)</p>	<p>Wetland Hydrology Indicators:</p> <p>Primary Indicators:</p> <p><input checked="" type="checkbox"/> Inundated</p> <p><input checked="" type="checkbox"/> Saturated in Upper 12 Inches</p> <p><input checked="" type="checkbox"/> Water Marks</p> <p><input checked="" type="checkbox"/> Drift Lines</p> <p><input type="checkbox"/> Sediment Deposits</p> <p><input type="checkbox"/> Drainage Patterns in Wetlands</p> <p>Secondary Indicators (2 or more required):</p> <p><input checked="" type="checkbox"/> Oxidized Root Channels in Upper 12 Inches</p> <p><input type="checkbox"/> Water-Stained Leaves</p> <p><input type="checkbox"/> Local Soil Survey Data</p> <p><input checked="" type="checkbox"/> FAC-Neutral Test</p> <p><input type="checkbox"/> Other (Explain in Remarks): _____</p>
Remarks: _____	



Wetland  
Determination  
Data  
Site.

5' INTERIOR GEOLOGICAL SURVEY, RESTON, VIRGINIA 1973: FESTUS 2.2 MI. R. 5 E. 1729000m E. 38°15' 90°22'30"

FESTUS 2.4 MI. 1729000m E. 38°15' 90°22'30"

#### ROAD CLASSIFICATION

Heavy-duty ——— Light-duty ———  
Medium-duty ——— Unimproved dirt ———

○ Interstate Route □ U. S. Route ○ State Route



QUADRANGLE LOCATION

HERCULANEUM, MO.  
SW/4 KIMMSWICK 15' QUADRANGLE  
N3815-W9022.5/7.5

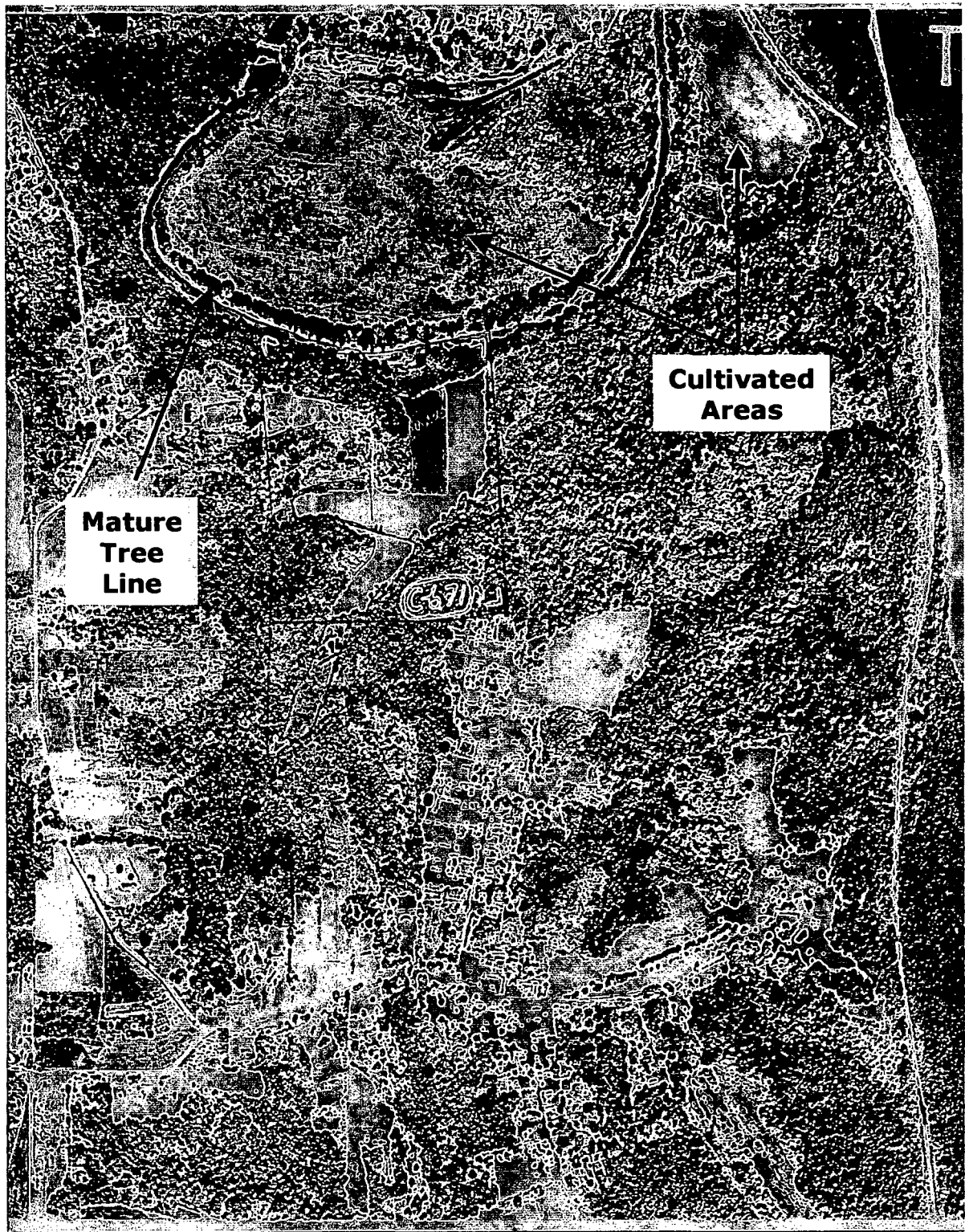
1954

PHOTOREVISED 1963 AND 1971

## **APPENDIX D**

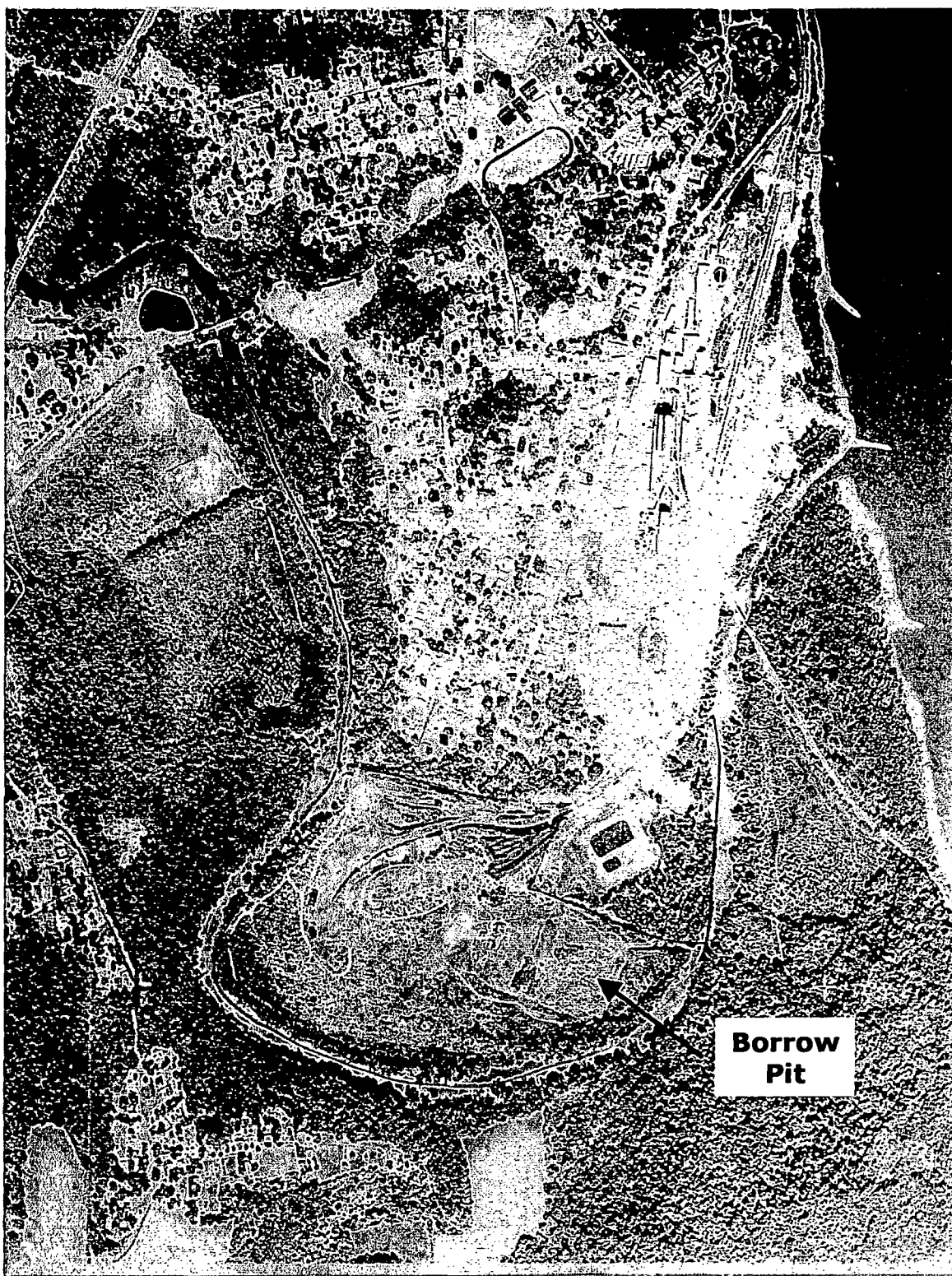
### **HISTORICAL AERIAL PHOTOGRAPHS**

- **1966 PHOTOGRAPH;**
- **1978 PHOTOGRAPH;**
- **1993 PHOTOGRAPH**



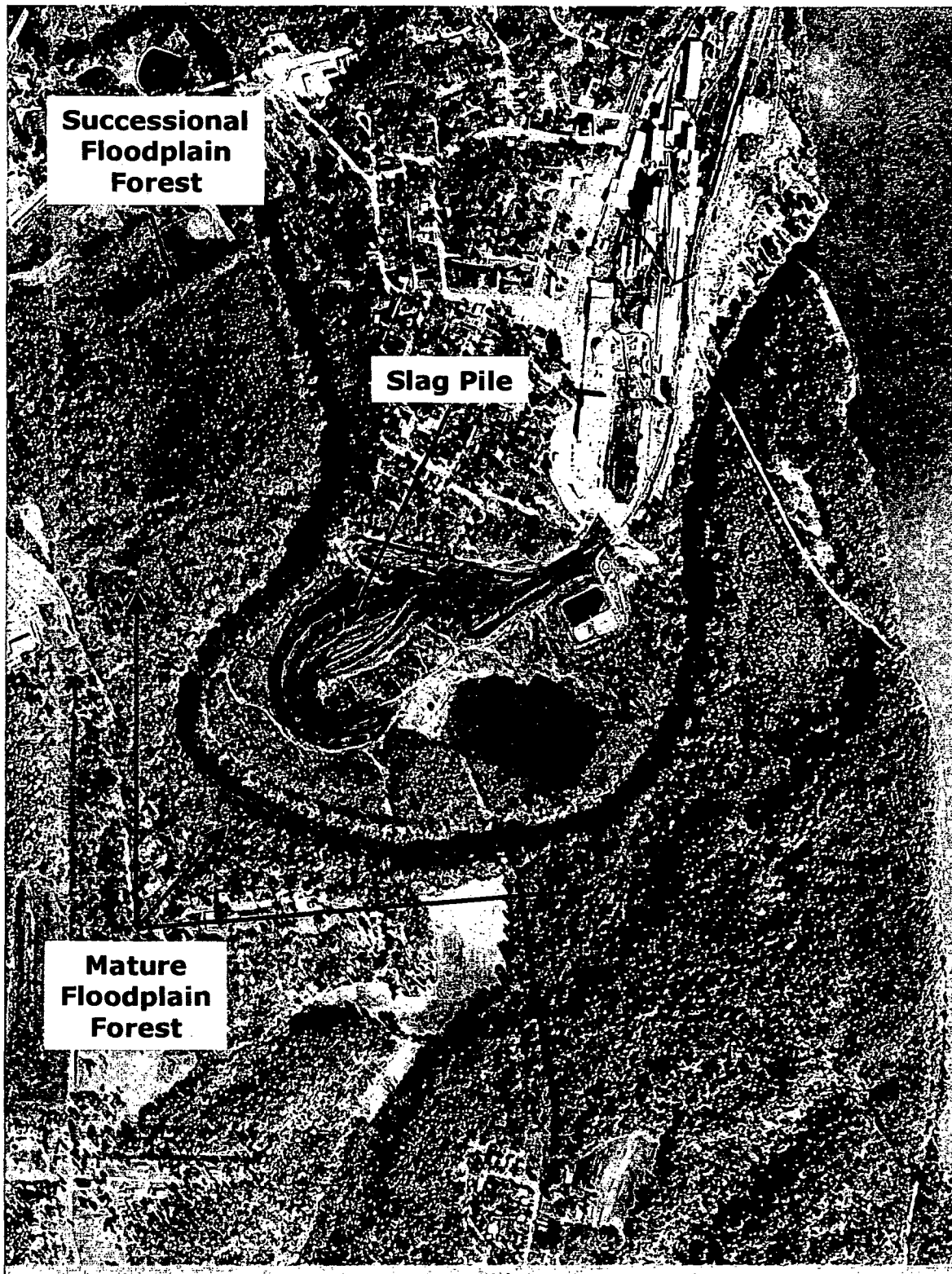
**Slag Investigation  
Historical Aerial Photograph  
1966**

Photograph obtained from the Jefferson County Soil & Water Conservation District



**Slag Investigation  
Historical Aerial Photograph  
1978**

Photograph obtained from the Jefferson County Soil & Water Conservation District



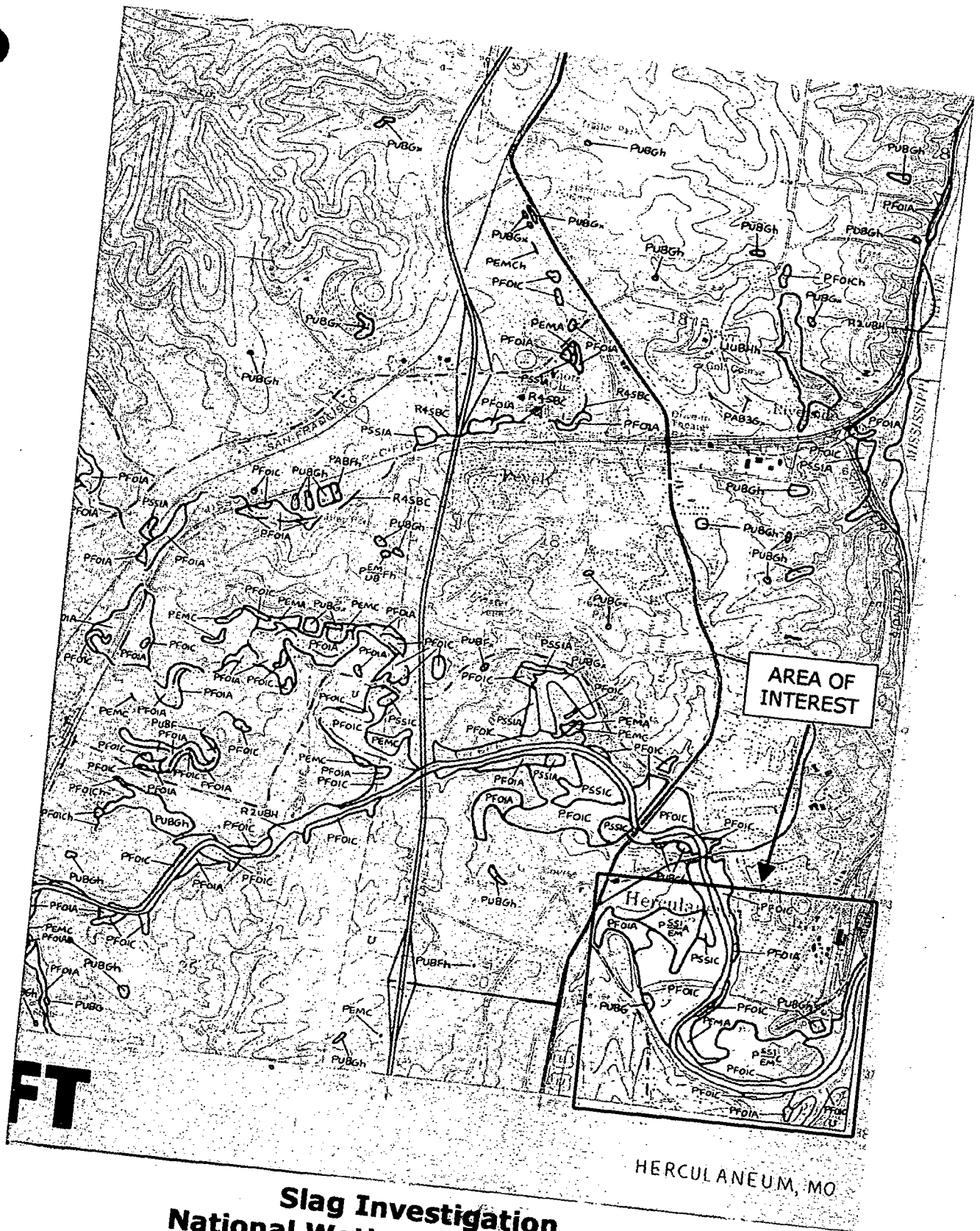
**Slag Investigation  
Historical Aerial Photograph  
1993**

Photograph obtained from the Jefferson County Soil & Water Conservation District

**DRAFT**

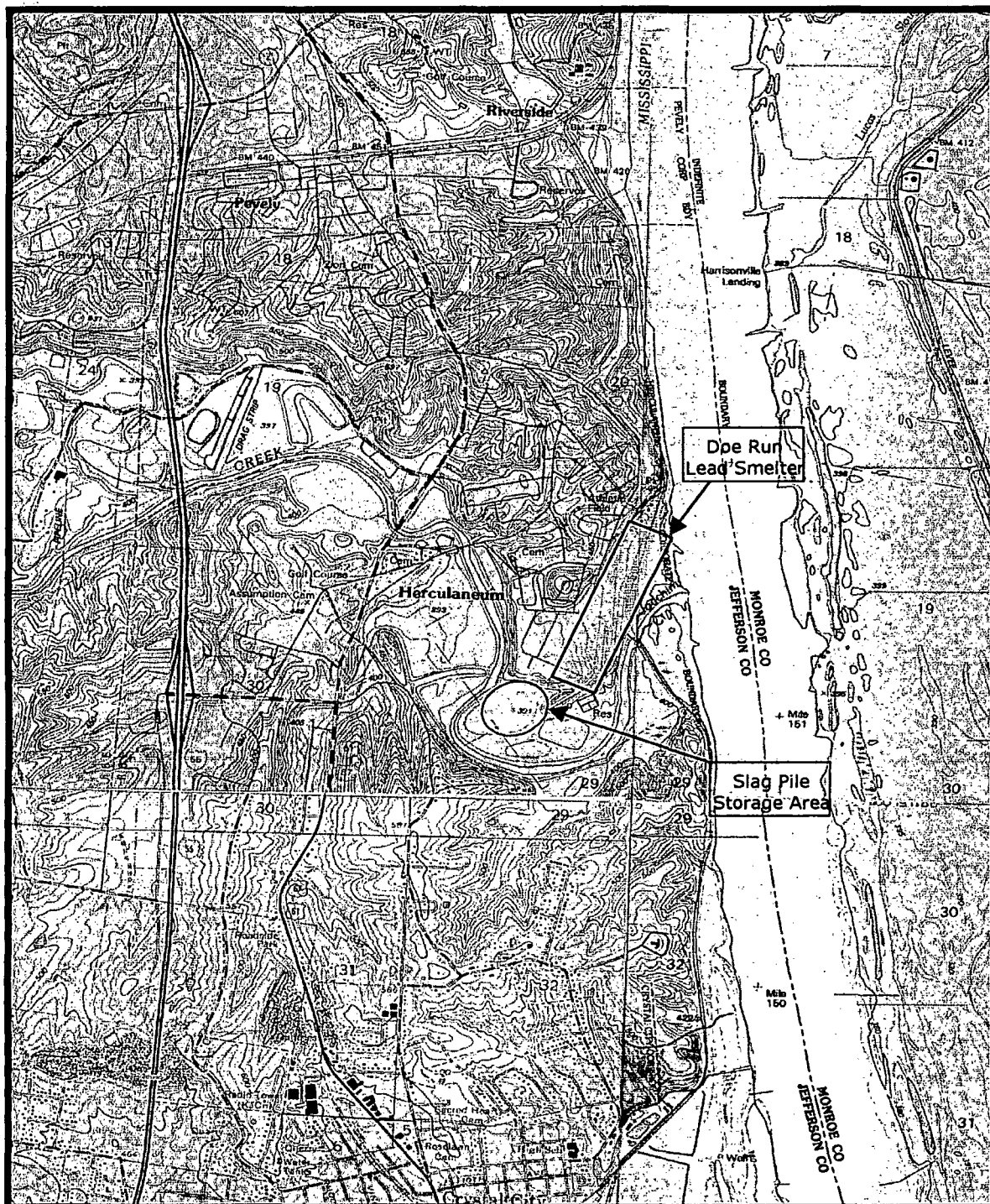
# **APPENDIX E**

## **WETLAND INVENTORY MAP**



**Slag Investigation  
National Wetland Inventory Map**

Photograph obtained from the Jefferson County Soil & Water Conservation District



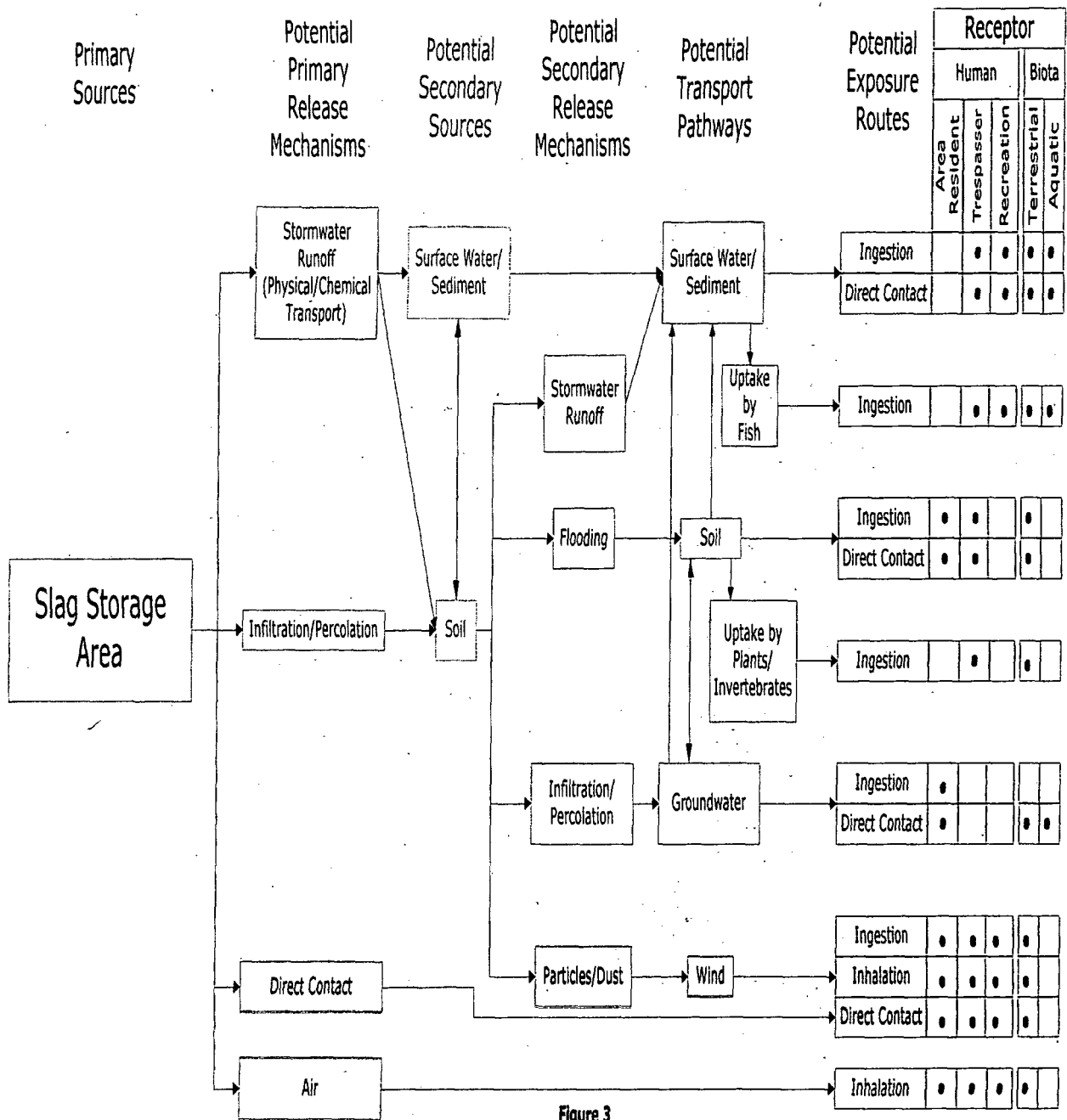
**Figure 1**

**Site Map  
Slag Investigation  
The Doe Run Company Lead Smelter-Herculaneum, Missouri**

Scale: 1"=2000'



Map Sources: U.S.G.S. Herculaneum, MO Quadrangle-1993  
 U.S.G.S. Festus, MO Quadrangle-1964 (photorevised 1982)  
 U.S.G.S. Selma, MO Quadrangle-1993  
 U.S.G.S. Valmeyer, IL Quadrangle-1993



**Figure 3**  
**Preliminary Conceptual Site Model**  
**Slag Investigation**  
**The Doe Run Company Lead Smelter-Herculaneum, Missouri**

Primary Sources

Potential Primary Release Mechanisms

Potential Secondary Sources

Potential Secondary Release Mechanisms

Potential Transport Pathways

Potential Exposure Routes

Receptor			
Human	Biota		
		Area Resident	
		Trespasser	
		Recreation	
		Terrestrial	
		Aquatic	

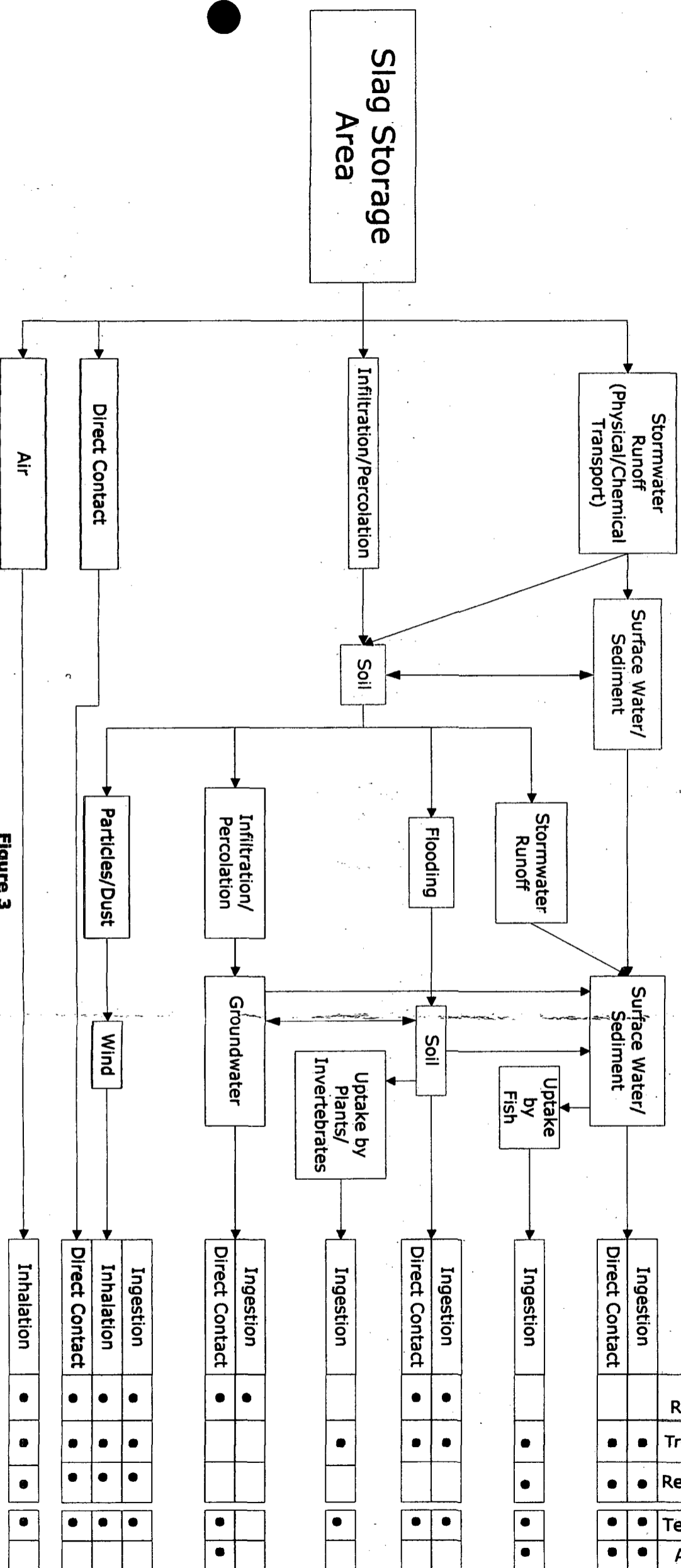


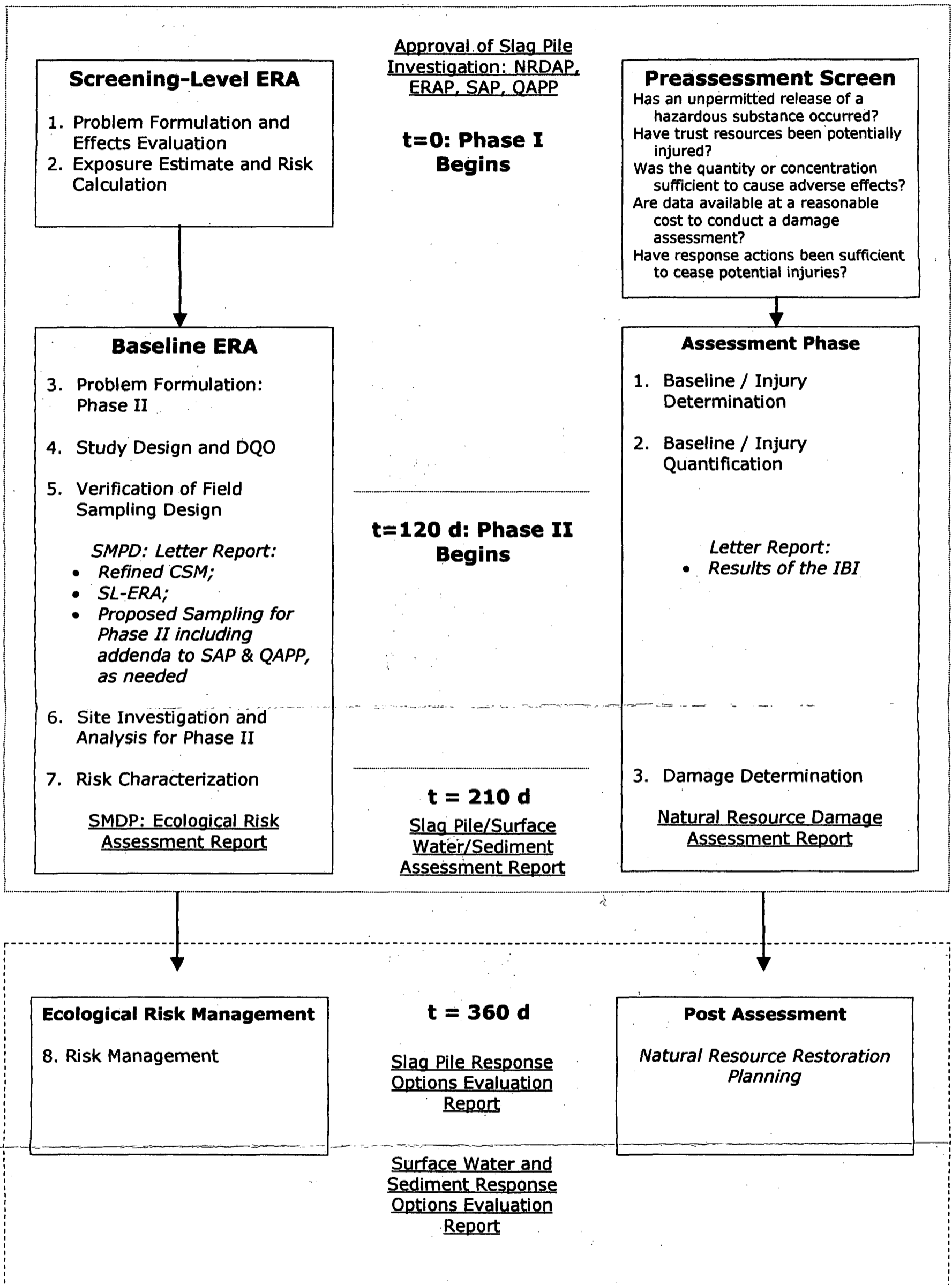
Figure 3  
Preliminary Conceptual Site Model  
Slag Investigation

The Doe Run Company Lead Smelter-Herculeaneum, Missouri

**ERA**

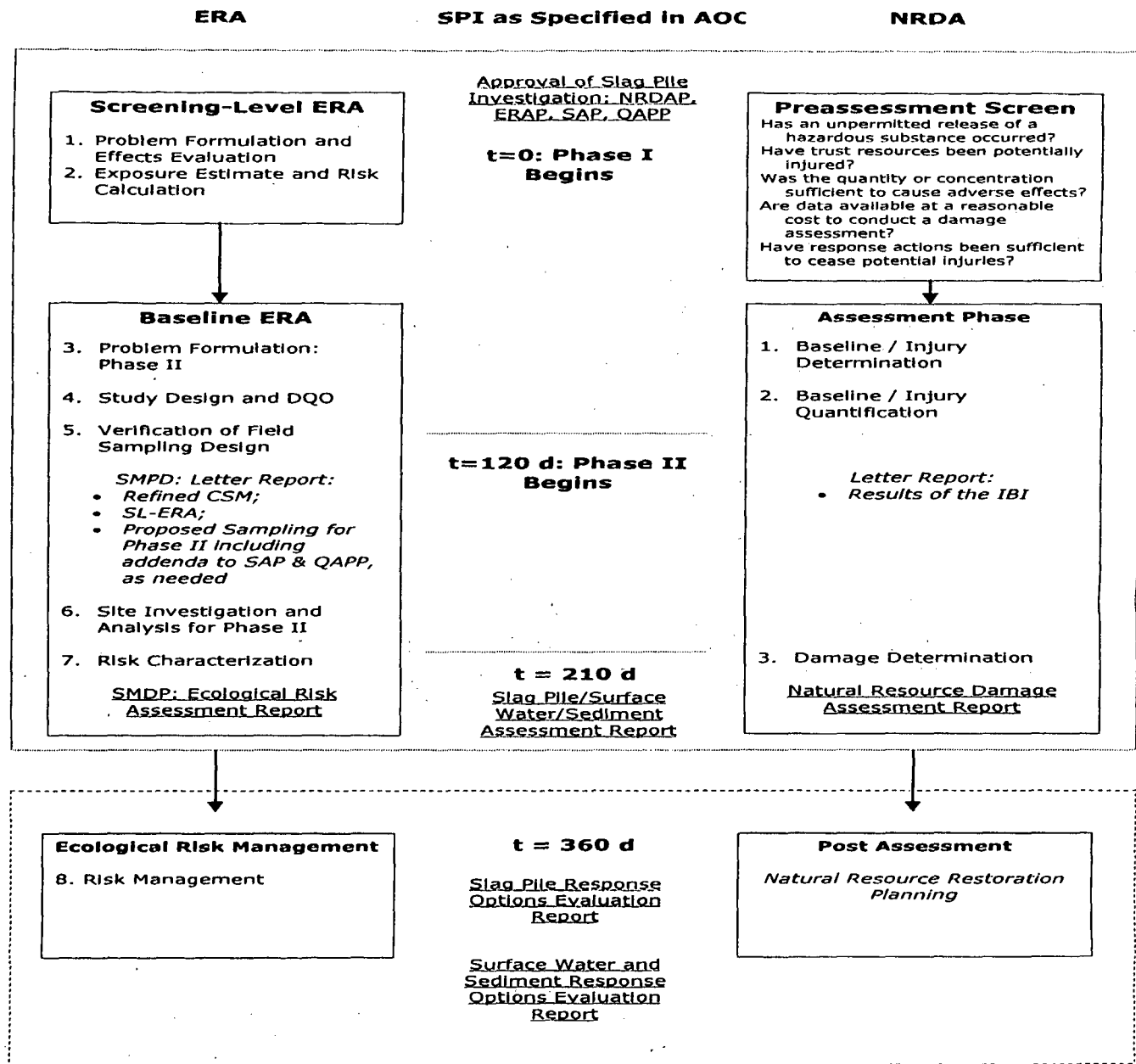
**SPI as Specified in AOC**

**NRDA**

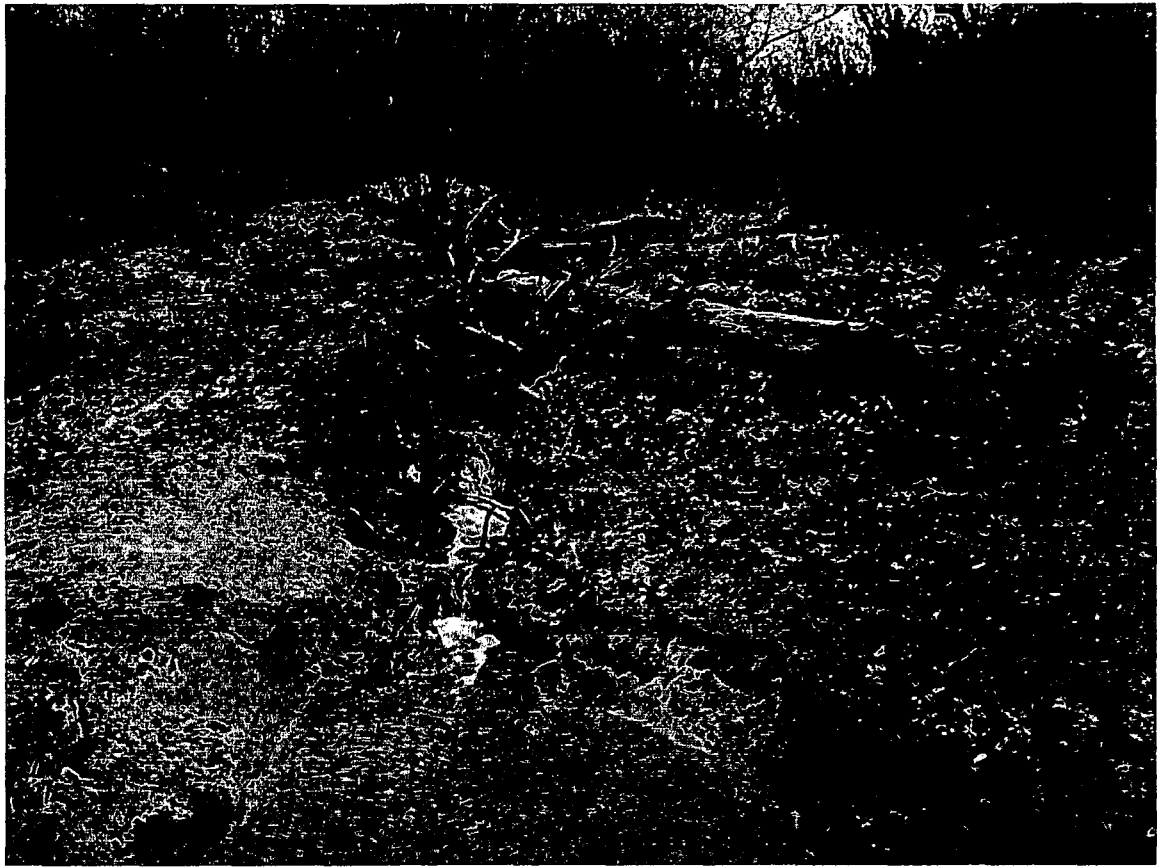


**Figure 2**

Conceptual design for the integration of the ERA and NRDA within the project objectives and deliverables specified by the AOC for the Slag Pile/Surface Water/Sediment/Groundwater investigation. Underlined text indicates deliverables from Doe Run specified by the AOC, while text in italics indicates interim deliverables in which input from the BTAG and Trustees are required.



**Figure 2**  
 Conceptual design for the integration of the ERA and NRDA within the project objectives and deliverables specified by the AOC for the Slag Pile/Surface Water/Sediment/Groundwater Investigation. Underlined text indicates deliverables from Doe Run specified by the AOC, while text in italics indicates interim deliverables in which input from the BTAG and Trustees are required.



**Figure 7**

This stream of water is discharging from the shallow borrow pit adjacent to the slag storage area. The borrow pit appears to accumulate precipitation and groundwater that originates from the Site.



**Figure 5**

View of slag storage area from access road looking west. Deposit in the foreground appears to be primarily from the access road. Standing water appears to include upwelling groundwater along the toe of the slope as well as precipitation.



**Figure 6**

Typical view of the toe of the slag storage area. Vegetation appears to be encroaching on the toe of the slope and very little rill erosion is evident.

# **Unscanned Document**

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